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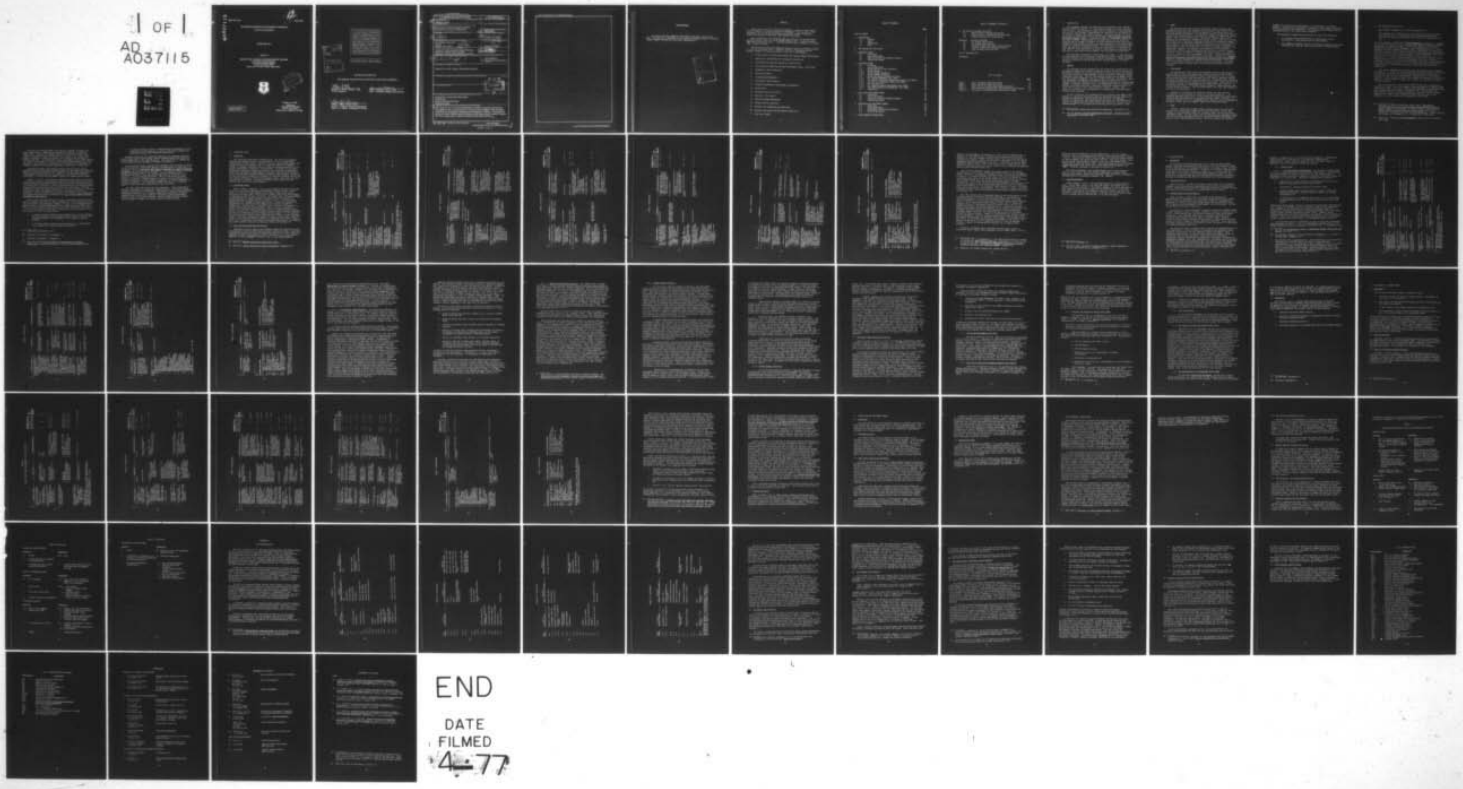

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FEBRUARY 1977

Prepared for

DEPUTY FOR COMMAND AND MANAGEMENT SYSTEMS
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
Hanscom Air Force Base, Bedford, Massachusetts

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Prepared by
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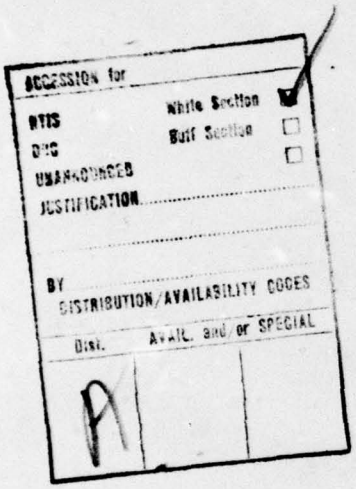

REVIEW AND APPROVAL

This technical report has been reviewed and is approved for publication.

William J. White

WILLIAM J. WHITE, Captain, USAF
Project Engineer

John T. Holland

JOHN T. HOLLAND, Lt Col, USAF
Chief, Techniques Engineering Division

Frank J. Emma

FRANK J. EMMA, Colonel, USAF
Director, Computer Systems Engineering
Deputy for Command & Management Systems

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This report is one of a series of guidebooks for software acquisition management. The guidebooks are being prepared for use by Air Force Program Office personnel responsible for planning and managing the development of software. This guidebook explains the Major Defense System Acquisition Life Cycle and the Computer Program Life Cycle as they apply to Electronic Systems that include software.

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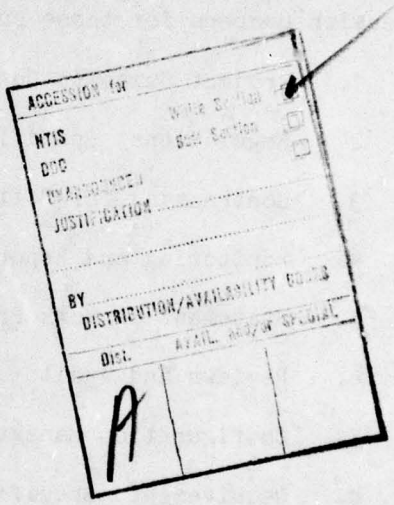

PREFACE

This report is one of a series of guidebooks intended to help Program Office personnel in software acquisition management. The contents of the guidebooks will be revised periodically to reflect changes in software acquisition policies & practices, and feedback from users.

This guidebook has been prepared under the direction of the Electronic Systems Division (ESD), Air Force Systems Command (AFSC), Computer Systems Engineering Directorate (MCI). Contributions were made by Captain W. J. White (MCI) (Project Officer).

The Software Acquisition Management Guidebook series is currently planned to cover the following topics. (National Technical Information Service accession numbers for those published to date are in parentheses).

1. Project Guide to Content Requirement and Audience Needs (AD-A019124)
2. Regulations, Specifications & Standards (AD-A016401)
3. Contracting for Software Acquisition (AD-A020444)
4. Monitoring and Reporting Software Development Status (AD-A016488)
5. Statement of Work Preparation
6. Reviews and Audits
7. Configuration Management
8. Requirements Specification
9. Software Documentation Requirements (AD-A027051)
10. Verification
11. Validation and Certification
12. Overview of the Series
13. Computer Program Maintenance
14. Software Quality Assurance
15. Software Cost Estimating and Measuring
16. Software Development and Maintenance Facilities
17. Life Cycle Events

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1. INTRODUCTION

This guidebook explains the Acquisition Life Cycle* for Major Defense Systems (defined in Section 1.1), the Computer Program Life Cycle, and their relationships. Some knowledge of these topics is essential to understanding the roles of the Government organizations and contractors in the acquisition of Electronic Systems that include software. Electronic Systems are one of seven types of system identified in MIL-STD-881A, Work Breakdown Structures for Defense Material Items. A substantial number of ESD-managed systems are Electronic Systems. This material is presented partly for the benefit of those who may be assigned to prepare or review software-related acquisition documents without formal training or extensive experience in Air Force system acquisition programs involving software. The guidebook also identifies many tasks that should be considered for possible incorporation in Statements of Work (SOWs)**, notes appropriate products of these tasks, and discusses the Regulations, Specifications and Standards that prescribe and define them.

The guidebook's treatment of these topics is minimal. It consists mainly of short summaries, plus references to Regulations, Specifications, Standards, and other sources that provide more definitive information. These references should be reviewed by those who need a more thorough grasp of the topics addressed.

1.1 Purpose

The guidebook has been prepared for use by Air Force Program Office (PO) personnel in general and a person termed the Software Director in particular. The Software Director is the military officer or civilian within the Program Office who assists the Program Manager (PM) in planning and managing software development activities. As such, the Software Director is one member of an Air Force program management team that includes technical, procurement, legal, data management, configuration management, and other specialists whose combined efforts are necessary for the successful completion of an acquisition program. Different individuals (e.g., the Engineering Division director) may perform the Software Director's functions in different Program Offices, or these functions may be split among different persons. However, with appropriate allowance for such variations in organization, this guidebook's contents apply unchanged.

Unlike a directive, this guidebook does not prescribe what must be done. Instead, it identifies issues and pitfalls; references relevant sections of appropriate Regulations, Specifications and Standards; and suggests alternative approaches. Any questions that may arise over the feasibility or legality of suggestions made herein should be referred for decision to the Program Manager or to the appropriate Procuring Contracting Officer (PCO).

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* The guidebook capitalizes specialized terminology. See Section 1.3.

** See the Software Acquisition Management Guidebook: Statement of Work Preparation (abbreviated SOWG).

1.2 Scope

The guidebook explains the chief activities, events, products, and software-related effort that normally occur during the life cycles of major Electronic Systems acquired within the framework of the 800-series of Air Force regulations and manuals. The 800-series normally governs acquisition of computers and software which are embedded in a weapons or command and control system. Some of this software (e.g., Application Programs) may be built expressly for the weapons or command and control system. Some (e.g., certain Operational Executives) may be modified versions of off-the-shelf software. A third subset (e.g., Compilers, Assemblers) may consist of unaltered off-the-shelf software. The 800-series covers the research, design, development, engineering, testing, and production of tactical & strategic systems for the operational inventory. In contrast, the acquisition of off-the-shelf, commercially marketed data processing equipment and its associated support ("non-functional") software for business-like applications (e.g., payrolls, logistics, personnel records, management reporting) is normally governed by the 300-series of Air Force regulations and manuals. ESD-TR-75-91, Software Acquisition Management Guidebook: Regulations, Specifications and Standards, Chapter 2, further compares the 300-series and the 800-series. This Life Cycle Events guidebook does not address acquisitions managed in accordance with the 300-series, although some of its principles may apply there and elsewhere.

1.3 Conventions

The Regulations, Specifications and Standards on which this guidebook is largely based use many terms drawn from ordinary English in special ways. These directives define acronyms for some of these terms but not for others. Where acronyms are used, they help make clear the special meanings intended, but where no acronym is used confusion may arise. To minimize this problem in the guidebook terms used in special ways are capitalized. These special terms are usually defined in the guidebook section where they first occur, or in references cited there. The guidebook uses acronyms in common parlance, and certain others for brevity. Each is defined where first used, and repeated in the List of Abbreviations.

Readers can distinguish the direction, advice, and other options interspersed in the guidebook by noting the following conventions. To designate mandatory action (e.g., action prescribed by applicable Regulations, Specifications and Standards) the guidebook employs "must" or "shall". In contrast, "should" or "it is recommended that", identify action recommended by the author, while "may" and "might" connote other optional actions.

1.4 Plan

Section 2 introduces the Major Defense System Acquisition Life Cycle. Sections 3-5, respectively, summarize the chief activities, events, and products of its Conceptual Phase, its Validation Phase, and its Full-Scale Development Phase. Section 6 deals with its Production and Deployment Phases. Section 7 discusses the application of Major Defense System Acquisition Life Cycle events to Less-Than-Major Systems. Section 8 explains the Computer

Program Life Cycle and its relationship to the Acquisition Life Cycle. Appendix A discusses the Specifications, because of their special importance in system definition and acquisition. The guidebook also includes a List of Abbreviations and a list of pertinent references.

The guidebook's organization anticipates its use in two main ways:

a. as a tutorial for persons relatively inexperienced in the acquisition of large systems that include software;

b. as a summary of material relevant to software acquisition for those otherwise quite familiar with the acquisition of large systems.

2. THE ACQUISITION LIFE CYCLE

MIL-STD-881A (paragraph 3.14) defines Acquisition as

> "the aggregation of efforts to develop, produce and provide a weapon system to the user. It commences in the conceptual phase and is completed at such time as the last production unit is provided to the user."

Air Force Regulation (AFR) 800-2, Program Management (Attachment 1, paragraph 4), defines the Acquisition Life Cycle for Major Defense Systems as normally comprising five sequential phases: Conceptual, Validation, Full-Scale Development, Production and Deployment. Major Defense System (i.e., "major program") status is assigned by the Secretary of Defense or his Deputy to a system whose acquisition is planned, based on estimated Research, Development, Test, and Evaluation cost greater than $50 million, estimated production cost greater than $200 million, national urgency, or other important considerations. Defense Systems Acquisition Review Council (DSARC)* review normally follows each of the first three phases, after each of which a favorable decision by the Secretary of Defense is required for the acquisition to proceed into the next phase. AFR 800-2 terms these three decisions the Program Decision, the Ratification Decision and the Review Decision,** respectively.

DODI 5000.2 (paragraph IV.B) defines the same decision points slightly differently. It states that these are normal, but also provides for different or additional major decision points established jointly by the Military Services and the Office of the Secretary of Defense (OSD) if they deem it worthwhile. Each of these decision points permits the Secretary of Defense to redirect a major program in trouble, or to cancel it, without total loss of planned investment.

While the agendas of the different DSARC reviews differ significantly because the system under review changes during development, all DSARC reviews have certain common objectives. These include assuring continuing operational need, adequate system performance, acceptable cost, and favorable cost effectiveness relative to other alternatives. Naturally, the anticipated agenda of each DSARC review strongly influences the work done in the Acquisition Life Cycle phase that culminates in that review.

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* Department of Defense Instruction (DODI) 5000.2, The Decision Coordinating Paper (DCP) and the Defense Systems Acquisition Review Council (DSARC), and Department of Defense Directive (DODD) 5000.26, Defense Systems Acquisition Review Council (DSARC) define DSARC composition, responsibilities and operating procedures. These directives are included as Attachments 4 & 5, respectively, to AFR 800-2.

** AFSCP 800-3, A Guide to Program Management, terms this the Production Decision.

A Decision Coordinating Paper (DCP) must be prepared to support each normal DSARC review. These DCPs are termed DCP I, DCP II, and DCP III, respectively. Limited to 20 pages, each DCP is required* to record the essential information about the system and its status (e.g., need, threat, concept, milestones, unresolved issues), and eventually the Secretary of Defense's decision. The latest DCP is also expected** to be reviewed annually and revised as necessary to reflect significant program changes; e.g., cost estimates. Thus, review of a system's latest DCP version, if available, is strongly recommended as important background information in compact form.

Assuming the normal three decision points, the objectives, initial conditions, major activities, and major products of the Acquisition Life Cycle phases are outlined in Sections 3-6. However, note that under appropriate circumstances a program may skip a phase# (e.g., the Production Phase in acquisition of a one-of-a-kind Command, Control and Communications system).

Tables 1, 2, and 3, respectively, summarize the major types of activity, other events, products, and software-related effort that occur in each of the Conceptual Phase, the Validation Phase, and the Full-Scale Development Phase of the Acquisition Life Cycle. Some of these products are contractor-prepared documents whose content and format are prescribed by Government Data Item Descriptions (DIDs) (see SOWG, Section C2.7). In each of Tables 1-3, the name or acronym of each such document is followed in brackets by its DID's identifier. Further information about most of the document types mentioned in this guidebook may be found in ESD-TR-76-159, An Air Force Guide to Software Documentation Requirements.

These tables also indicate typical roles of Government participants and types of contractor support that may be appropriate. The Government roles can vary considerably from program to program. For each Air Force-managed Major Defense System, a Program Management Directive (PMD) specifies these roles. Some of the most important table entries are further explained in Sections 3-5. A type of activity or other event is mentioned in one of Tables 1-3 if it satisfies any of the following criteria.

a. It entails software-related effort properly done only by Government (including Federal Contract Research Center (FCRC)) personnel; for example, preparation of independent cost estimates is such an activity.

b. It involves software-related work appropriate for a contractor## (e.g., application computer program development).

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* DODI 5000.2, paragraph IV.A.2.

** DODI 5000.2, Enclosure 1, paragraph I.G.

\# AFR 800-2, Attachment 1, paragraph 1.

ESD-TR-75-365, An Air Force Guide to Contracting for Software Acquisition, provides an overview of what such contracting involves.

c. It directs policies, actions, organizational relationships or other constraints on the system (e.g., use of a particular computer and executive software) that may affect acquisition.

Analogous tables for the Production Phase and the Deployment Phase are not provided, because these phases' simpler software-related activities are readily summarized in text (see Section 6). The acquisition of systems that do not qualify as major programs is touched on in Section 7.

The activities, events, products and Government roles mentioned in Tables 1-3 and in Sections 3-6 are based mainly on interpretation of AFSCP 800-3, on AFR 800-14, Vol. II, Acquisition and Support Procedures for Computer Resources in Systems, on AFR 800-2, and on DODI 5000.2. The tabular material is grouped somewhat differently than in its sources. The corresponding types of software-related effort have been identified partly on the basis of the author's acquisition program experience. Each of these tasks is either necessary to develop a required product; or else is usually essential to accurate forecasting, to sound design and planning, or to good management of software development. The tables also suggest the type(s) of contractor support (if any) that may be appropriate to each such task.

Note that contractor support is never mandatory. Given enough expert manpower, Government (including FCRC) personnel may do almost any software-related task as well as a contractor. Some types of task, including Technical Performance Prediction (e.g., computer simulation and analysis of system response times), may be done better by technically qualified Government personnel than by contractor personnel, because typically greater insight, faster response to change, and better control are then possible.

3. CONCEPTUAL PHASE

3.1 Objectives

The Conceptual Phase has two primary goals. The first is to explore, formulate and evaluate possible requirements for a new or significantly improved Major Defense System. Second, if the need appears great enough, the Conceptual Phase work should devise, for DSARC and Secretary of Defense review, an optimum, affordable, and cost effective preferred approach to the system's development, production, and deployment. In support of this goal, considerable preliminary design and analysis of software may be appropriate. Except for development of demonstration, prototype, and simulation software, such Conceptual Phase software design and analysis should normally be limited in level and scope to whatever is necessary to establish technical feasibility and credible estimates of costs and development times. This level will vary from function to function. Design and analysis should normally be most detailed where technical risk is greatest.

3.2 Initiating Events

Refer to Table 1, Sets A-F. An Air Force system's Conceptual Phase may be said to have started whenever the Department of Defense (DoD), the Air Staff, or a major Air Force command directs studies that reveal serious deficiencies in some aspect of our national defense posture and which suggest a promising approach to their correction. One common type of Conceptual Phase initiating event is a major command's submission to the Air Staff of a Required Operational Capability (ROC)* (Table 1, Set C). A ROC describes deficiencies in a command's systems that prevent it from fully meeting its responsibilities; the ROC may also suggest new or improved corrective capabilities. Another type of initiating event could be the formation of a special Mission Analysis Steering Group, (Table 1, Set B), chaired by a specific Air Force operational command, to explore alleged deficiencies in a system or mission area. Conceptual Phase activity could also begin informally as a result of needs revealed by routine planning studies. If its review of the ROC Evaluation, Mission Analysis Steering Group Report, or other planning studies is favorable, Headquarters USAF will issue an initial PMD. This PMD (Table 1, Set E) constitutes the authority to establish the PO Cadre (Table 1, Set F) and to begin major expenditure on Conceptual Phase effort. The PMD may also direct specific studies or development considered desirable.**

3.3 Other Activities and Related Products

Regardless of how it begins, the Conceptual Phase will typically include the activities, and yield the related products, outlined in Table 1, Sets G-U. Considerable variation in these activities and products will occur among major programs, because of differences in formal direction (e.g., in the terms of PMDs) and in local management decisions (e.g., by the Program Manager).

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* AFR 57-1, Required Operational Capabilities (ROCs).

** AFR 70-15, Source Selection Policy and Procedures, paragraph 2-1a.

Table 1

Major Conceptual Phase Activities

SET	Activity or Event	Product(s)#	Software-Related Effort	OSD	USAF	OPER	AFLC	ATC	AFSC	ICS	PO	PCO	FCRC	Type of Contract Support*
				Government Roles*										
A.	Suggest needed operational capability	None specified**	None	I	I	I			I	I			A	U
B.	Form Mission Analysis Steering Group to 1. Examine a mission area 2. Identify deficiencies 3. Suggest new system concepts	Mission Analysis	Summarize capabilities & limitations of existing systems' software		R	O	P		G	P			A	A
C.	Prepare Required Operational Capability (ROC) that 1. Identifies deficiencies 2. Suggests solutions	ROC	Summarize capabilities & limitations of existing systems' software		R	O				A			A	A
D.	Evaluate statement of need (e.g., ROC) 1. Assess threat 2. Assess deficiencies in current systems vs. threat 3. Identify alternatives to meet need 4. Evaluate each alternative's technical feasibility 5. Estimate feasible alternatives' performance, costs, development times and risks	Mission Analysis, or ROC Evaluation Group Report	1. None 2. Assess current & existing alternate systems' software by document review & selective testing 3. Define alternatives to the software subsystems identified 4-5. Estimate alternatives' sizes, performance, development times, costs & risks as well as possible	R	R	P	P		O	P			A	A
E.	Issue guidance for program 1. Prepare & issue Program Management Directive (PMD) & supplementary guidance 2. Establish program priority	PMD; AFSC Form 56	None		O		A		G	A				U
F.	Establish PO Cadre	None specified**	None		I	A	A		G	A				U

* See KEY on final page.

** "None specified" means that no directive reviewed specifies a particular form for this product. Hence, memoranda or technical reports would be used as appropriate.

\# Products' DID numbers are bracketed when first named.

Table 1 (Continued)

SEI	Activity or Event	Product(s)#	Software-Related Effort	Government Roles[@]								Type of Contract Support[@]
				USD	OSF	OAR	PEC	ALC	AFC	ITC	SCS	PQO	CQC	FCR	
G.	Plan use of any pertinent results from Advanced Development Program (a R&D program) to show feasibility	Preparation for Feasibility Demonstration could yield: 1. Plan for Validation Phase Feasibility Demonstration 2. Feasibility Demonstration software [E-129] to prove concept of risky algorithms 3. Technical reports [S-3591A]	1. Invent or adapt critical algorithms 2. Develop Feasibility Demonstration software; i.e., the subset of the Executive, Application Programs, test drivers, and data reduction packages necessary to risk reduction 3. Write or review reports		R						O		P	D
H.	State operational requirements	Operational Concept	None	I	O	A		A		C		A		U
I.	Preliminary system design studies (paper): 1. Define system workload(s) 2. Identify desired outputs 3. Define alternative systems, & for each define as necessary to judge feasibility: a. Functional Areas & perhaps lower level components b. External & internal interfaces c. Equipment-software tradeoffs	None specified[**]	1-2. Help to translate operational workloads & outputs into computer workloads for quantitative analysis 3. Define alternative systems; for each: a. Invent, adapt, or approve proposed algorithms; b. Define or approve software subsystems' allocation of functions & interface characteristics; c. Do or approve software size, execution time, development time, cost & risk estimates		R	P					O		P	S,B,E
J.	Assess technical feasibility & risk 1. Compare & rank competing alternatives for: a. Technical feasibility b. Ability to meet operational requirements c. Performance (e.g., response time per workload, reliability, availability) d. Technical risk	1. Technical reports [S-3591A] of: a. Simulation program design b. Simulation program results c. Queuing analysis/performance predictions d. Alternatives considered, assessment procedures, & results	1. Simulate alternate designs a. Develop computer program for discrete event simulation of alternative system/subsystem designs vs. key workloads b. Develop workload-simulation program to drive system simulation c. Run simulators to predict response times, queue lengths, etc., under workloads to be handled		R	C	A				O		P	B,D,E,P

Table 1 (Continued)

S E I	Activity or Event	Product(s)#	Software-Related Effort	Government Roles*										Type of Contract Support*
				O S D	U S A E	O P E R	A F L C	A T C	A F S C	I C S	P O	P C O	F C R C	
J.	2. Improve alternate designs	2. Machine-readable simulation software [E-129]	2. Reflect results in improved alternate designs											
	3. Identify Functional Areas & components needing selective development, demonstration & testing in Validation Phase	3. Technical Reports [S-3591A]	3. Identify software components needing selective development, etc.											
K.	Assess production feasibility 1. Identify problems 2. Estimate production costs, schedule impacts & results	None specified**	Essentially none				G		R	G	O		A	A
L.	Estimate logistic support needs	None specified**	Essentially none	R	A	P				G	O		A	A
M.	Make preliminary test estimates	Technical reports [S-3591A]; possible draft TEMP	Estimate needed software development and maintenance facility needs	R	P	P					O		P	A
	1. Identify types of testing wanted		1. Identify desired software test approach a. sequence of entities to be tested b. tools desirable c. facilities needed d. other constraints											
	2. Indicate needed test facilities		2. Estimate computer time											
	3. Outline desirable test tools 4. Allocate responsibilities 5. Prepare rough test schedule		3. Estimate manpower by type											
N.	Prepare preliminary cost & schedule estimates	None specified** except for WBSs (see SOWG, Appendix A)	For preliminary estimates:	R	A	A				P	O		A	A
	1. Develop Preliminary Work Breakdown Structures (WBSs)		1. Advise on breakdown of software-related tasks and related products											
	2. Estimate effort, costs, & time constraints		2.a. Estimate effort, times & costs to produce & test development software b. Estimate acquisition cost of existing software											
	3. Develop preliminary schedules based on above		3. Advise on software-related schedule entries											

Table 1 (Continued)

Activity or Event	Product(s)#	Software-Related Effort	OSD	USAF	OPER	AFLC	ATC	AFSC	ICS	PO	PCO	FCRC	Type of Contract Support*
O. Perform formal cost effectiveness analyses, optimizing different alternatives to reduce cost within acceptable performance, schedule, & risk limits	None specified**	For system design alternatives: 1. Change alternatives' software designs to reflect system changes 2. Modify accordingly estimated performance (e.g., via simulation), costs, schedules, & risks		R	A	A			P	O		A	A
P. Define & analyze procurement approach alternatives for all Acquisition Life Cycle phases 1. Government/contractor work breakdown allocation 2. Types of contract 3. Source selection approaches	Alternate Preliminary Summary Program Breakdown Structures (PBSs) (see SOWG, Appendix A)	For each alternative: 1. Advise on appropriate software work allocations 2-3. Provide data pertinent to contract type & Source Selection approach on potential contractors' capabilities & limitations		R		A			A	O	G	A	U
Q. Advocacy & planning 1. Brief higher headquarters on progress 2. Budget for proposed system 3. Specify issues to be treated in Draft DCP	Briefing material	Prepare software-related briefing material		O	A	A		A	A	P		A	U
R. Initiate Conceptual Phase DCP 1. Prepare initial draft using OSD-provided outline (if any) 2. Address directed topics; e.g.: a. Threat b. Operational need c. Proposed system functional & performance objectives d. Feasible alternatives, their pros & cons e. Avoidance of duplication f. Critical risks & related test objectives, schedules & milestones g. Preliminary cost & schedule estimates	Initial Draft DCP I	Possible special design, performance, risk evaluation, or cost/schedule studies		O	A	A		A	A	P		A	U

Table 1 (Continued)

SEI	Activity or Event	Product(s)#	Software-Related Effort	Government Roles*									Type of Contract Support*
				USD	OSAF	APER	AFLC	ATCC	FSCS	IPSO	PCQ	RC	
R.	2. h. Critical logistics support factors i. Critical issues & their resolution in Validation Phase j. Proposed cost, performance & schedule thresholds												
S.	Revise Air Force guidance												
	1. Modify PMD & supplementary guidance to reflect Air Staff response to Advocacy	1. Revised PMD & AFSC Form 56	1. Advise PM		O	A	A		G	A			U
	2. Prepare draft Validation Phase RFP(s)	2. RFP(s) for Validation Phase including Preliminary CWBS(s) and requiring a CPDP and a TEMP (see SOWG Appendix C)	2. Draft software-specific SOW sections & review related material		R	A	A			A	P	O	P	U
	3. Establish full PO	3. None specified**	3. Advise on candidates' qualifications		I	A	A		G				U	
T.	Complete & assemble Functional Baseline:				R		C	A			A	O	P	S
	1. Initial System Specification including: a. System performance goals b. Operational Concept c. Logistics Concept	1. Initial System Specification [E-3101]	1. Draft & review software-related sections of Initial System Specification											
	2. Revised cost & schedule estimates to complete selected approach	2. None specified**	2. Provide revised software-related cost & schedule inputs											
U.	Complete management planning documentation. Note: Program Management Plan includes:													
	1. PO Validation Phase objectives & methods 2. Program/Contractor relationships, including any Independent V&V 3. Program Cost/Schedule Control System 4. System security requirements 5. Master Program Schedule, including IOC dates 6. Program cost estimates	1. Program Management Plan (PMP) 2. System Command Information Plan 3. Determination & Findings 4. Procurement Plan 5. Preliminary Summary PBS 6. Source Selection Plan 7. Validation Phase RFP(s) 8. Initial TEMP 9. Logistics Support Plan 10. Production Plan 11. Real Property Facilities Plan 12. Environmental Assessment 11. Real Property Facilities Plan	1-12. Advise as requested 7. See SOWG 8. Provide software-related sections											

Table 1 (Concluded)

S & T	Activity or Event	Product(s)#	Software-Related Effort	Government Roles*										Type of Contract Support*
				OSD	USAF	OPER	AFLC	AFSC	ATC	ICS	PO	PCO	FCRC	
V.	DCP I Review/Approval													
	1. DSARC review, change & coordination of DCP I	1. "For comment" & "for coordination" drafts of DCP I	Possible "testimony" before DSARC	R	O	A	A		A		A			U
	2. SECDEF approval, redirection or cancellation of program (i.e., the Program Decision)	2. Approved DCP I or memorandum of direction												

KEY

Government Participants

- OSD = Office of the Secretary of Defense (e.g., Secretary, DSARC)
- USAF = Headquarters, USAF (i.e., Secretary or Air Staff)
- OPER = Operating Command (e.g., ADCOM, MAC, SAC)
- AFLC = Air Force Logistics Command
- ATC = Air Training Command
- AFSC = Headquarters, Air Force Systems Command
- ICS = Intermediate Command (e.g., ESD) Staff
- PO = Program Office (including PM)
- PCO = Procuring Contracting Officer
- FCRC = Federal Contract Research Center (e.g., MITRE)

Typical Government Roles##

- A = Advises or submits input
- C = Provides comments for coordination
- G = Provides supplementary guidance
- I = Initiates activity
- O = Office of primary responsibility
- P = Major participant in work
- R = Reviews & decides

Type of Contract Support##

- A = Ad hoc informal consultation
- B = Basic program or data base design
- D = Develop (e.g., design, code, document, test & integrate) CIs
- E = Estimate costs, schedule or risks
- P = Predict performance
- R = Critical review
- S = System or Segment design
- T = Test & integrate system or Segment
- U = Unwise (e.g., illegal, infeasible)

The Government roles and types of contractor support indicated apply to the entire set (e.g., Set A, Set C), or to the parts of the set (e.g., A.1.), with the description of which they line up.

However, the requirements for preparation of DCP I and for DSARC review, as specified in DODI 5000.2, tend to standardize Conceptual Phase activity somewhat for all Major Defense Systems. Besides the initial draft of DCP I, the Functional Baseline (defined in AFSCP 800-3, paragraph 2-21) and related management planning documentation (see Table 1, Sets T and U) are the chief Conceptual Phase products. Most of the other activities mentioned in Table 1 develop preliminary versions of similar products, and illustrate the iterative nature of much Conceptual Phase work.

The Functional Baseline includes the initial version of the System Specification.* This Initial System Specification should state the system's overall functional, performance, interface, design, and testing requirements. In addition, it should incorporate the system's first-level design, by identifying major parts of the system (termed Functional Areas), by defining the interfaces among them, and by allocating among them the system's requirements. If dividing the system into System Segments (see Section 4.3.3) is under consideration, the Initial System Specification may also identify these System Segments and the Functional Areas belonging to each. Conceptual Phase first-level design is preliminary. It is subject to change as a result of Validation Phase system definition and system design validation activities (see Section 4.3).

Note that several sets of Conceptual Phase activities mentioned in Table 1 include possible software-related work that might be contracted for, entailing preparation of one or more Conceptual Phase RFPs. This work includes preparation of Validation Phase Feasibility Demonstration software (Table 1, Set G); preliminary system design studies (Set I); system and subsystem simulation development, execution & modification (Set J); and drafting the Initial System Specification (Set T). Such work will tend to educate participating contractor personnel in the system's requirements. The Government may later benefit from this expertise if the participating Conceptual Phase contractors win related Validation Phase or Full-Scale Development Phase contracts. However, to avoid grounds for possible claims of bias by unsuccessful Offerers, competitive Validation Phase and Full-Scale Development Phase Requests for Proposal (RFPs) should be structured to give a fair chance to Offerers** without previous involvement in the system. For example, an RFP should allow a reasonable amount of time for competent Offerers to digest its system-specific material and to prepare sound proposals.

During the Conceptual Phase, Government personnel must prepare a Preliminary Project Summary Work Breakdown Structure (WBS) (Table 1, Set N),

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* AFR 800-14, Vol. II, paragraph 2-3. The System Specification is defined in MIL-STD-490, Specification Practices, paragraphs 3.1.3.1 and 10; and in MIL-STD-483(USAF), Configuration Management Practices for Systems, Equipment, Munitions, and Computer Programs, paragraph 30.

** Companies that submit proposals are termed Offerers.

alternate Program Breakdown Structures (PBSs)(Table 1, Set P), a Source Selection Plan,* a Procurement Plan,** and any Validation Phase RFP(s) (Table 1, Set U). The Software Director should prepare the software-related portions of these documents, and review the other portions. Other more specific plans may be obtained from Validation Phase (or Full Scale Development Phase) contractors by requiring them in RFPs. Noteworthy examples include a Computer Program Development Plan (CPDP) and a System Engineering Management Plan (SEMP). These are discussed in Sections 4.4.5 and 4.4.6.

Note that appointment of the Program Manager and PO Cadre formation (Table 1, Set F) occur only after several significant Conceptual Phase activities have begun. These early Conceptual Phase activities are managed by planning staffs at Intermediate Commands (e.g., ESD/XR).

3.4 Terminating Events

Refer to Table 1, Set V. The Conceptual Phase has no prescribed time limit. Before DSARC review of the draft DCP begins, the program can be terminated with the approval of the highest command level which authorized it. DSARC review follows a formal request by the Secretary of Air Force (SAF). Once DSARC review begins, the Conceptual Phase will normally end with the Secretary of Defense's Program Decision to proceed into the Validation Phase (with or without specific redirection), or to end the program.

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* AFR 70-15, paragraph 2-2.

** Air Force Armed Services Procurement Regulation (ASPR) Supplement 1-2100.50, and ESD-TR-75-365, paragraph 2.3.3.

4. VALIDATION PHASE

4.1 Objectives

The first main Validation Phase goal is to assess the Major Defense System's preferred design approach, selected as a result of Conceptual Phase activity (see Section 3.1), against the system's requirements (e.g., as stated in its Initial System Specification). If this approach proves unsatisfactory, a reasonable effort should be made to rectify it, or to develop and verify a better one. If and when a sound system design approach is achieved, the second main Validation Phase goal is to provide sound technical, contractual, economic, and organizational bases for the system's Full-Scale Development.

4.2 Initiating Events

Refer to Table 2, Set A. The Validation Phase begins with a favorable Program Decision (and possible supplementary direction) by the Secretary of Defense. Supplementary guidance from Headquarters USAF and from AFSC follows. This direction is consolidated in a revised PMD* and AFSC Form 56.

4.3 System Definition and Validation

Refer to Table 2, Sets B & E. As defined in the Regulations, Specifications and Standards, Validation Phase technical activities consist mainly of work to demonstrate the feasibility of doubtful components and subsystems, to refine the selected system design and interface definitions, and to improve related estimates of performance, cost and schedule. All can be considered risk-reduction measures.

In addition, it may be advisable to conduct, during the Validation Phase, a design competition open to industry, intended to develop if possible, and to verify, a better design than the preferred Conceptual Phase system design alternative. Such a design competition is especially desirable if the Conceptual Phase design effort was hasty or narrowly based. Besides soliciting better design concepts from new sources, a design competition can prevent or counter charges of unfair competitive practices. As an incentive, the design competition should be defined to accord the winner(s) a substantial Full-Scale Development Phase role.

The Validation Phase is intended both to reduce risk significantly and to allow negotiation of clear contracts (or analogous clear agreements among Government participants) for the subsequent acquisition phases. Thus, unambiguous specification of feasible and testable requirements during the Validation Phase is most important. During Full-Scale Development, significant disputes between the Government and a contractor or between the Implementing Command (e.g.; AFSC, represented by the Program Office) and other Government agencies doing development work, can easily arise over ambiguities or contradictions in specifications, SOWs, and other contract components. Thus, Validation Phase design and analysis should continue until the Program Office clearly understands the system definition, judges it desirable and

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* AFR 70-15, paragraph 2-1a.

feasible, and agrees that it has been precisely documented. Deciding when system definition is satisfactory is an important Program Office responsibility. Higher levels of authority (e.g., the DSARC) cannot be expected to detect all important design deficiencies.

4.3.1 System Design

4.3.1.1 Allocated Baseline Development. The Allocated Baseline (Table 2, Set E) is prescribed as the major Validation Phase product. Starting with the updated Functional Baseline (Table 2, Set B), Allocated Baseline development entails verifying or changing the system's first-level design, and extending it to a third level. First-level system design consists of:

a. subdividing the system defined in the System Specification into a number of components called Functional Areas*;

b. specifying the interfaces among the Functional Areas;

c. allocating among these Functional Areas the system's functional, technical performance, external interface, design, and testing requirements; and

d. if the system is to be segmented (see Section 4.3.3), identifying the System Segments, and the Functional Areas that belong to each Segment.

Second-level system design consists of similarly dividing each Functional Area into a number of components called Configuration Items (CIs)**, specifying their interfaces, and allocating the system's requirements among them. Software CIs, including both computer programs and computer data, are usually called Computer Program Configuration Items (CPCIs). However, unless otherwise qualified, the term Configuration Item applies to both equipment and software. Third-level system design similarly subdivides each CI into parts called Functions, which are defined in its Development Specifications.#

The Allocated Baseline is documented in a set of preliminary Development Specifications, one per CI. Also, a correspondingly revised version of the System Specification must be developed. AFR 800-14, Vol. II (paragraphs 2-4 &

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* MIL-STD-480, Configuration Control - Engineering Changes, Deviations, and Waivers, paragraph 110.27.

** MIL-STD-480, paragraph 110.80; MIL-STD-490, paragraph 10.3.1; and MIL-STD-483(USAF), paragraph 30.2.

\# MIL-STD-483(USAF), paragraph 60.4.3. The Functions of a CI should not be confused with a system's Functional Areas or with functional requirements; i.e., the definition of what a system (or one of its parts) must do. A software developer may be allowed freedom to redefine a CPCI's parts during its development. When such redesign occurs, the finished CPCI's major parts, termed Computer Program Components (CPCs), may differ from its Functions (see Section A4).

Table 2

Major Validation Phase Activities

S E I	Activity or Event	Product(s)#	Software-Related Effort	 O S D	U S A F	O P E R	A F L C	 A T C	A F S C	 I C S	 P O	 P C O	F C R C	Type of Contract Support*
	Government Roles*													
A.	Receive Program Decision & supplementary guidance													
	1. Program Decision via Secretary of the Air Force	1. Revised DCP I & possible memorandum of decision	None	I	O									U
	2. Budget Authorization & Program Authorization	2. BA/PA			O				G					U
	3. Program supplements to PMD	3. PMD and AFSC Form 56 updates			O				G	P				U
B.	Revise or complete Functional Baseline													
	1. Update System Specification to reflect changed (e.g., redirected) concepts	1. Revised System Specification [E-3101]	1. Review & revise software-related System Specification sections			C	A		R		O		P	S
	2. Update cost & schedule estimates	2. None specified**	2. Revise software development time & cost estimates		R	P	P		R	A	O		P	A
	3. Supply any previously TBD sections	3. None specified**	3. Supply software-related material			P	P		R	A	O		P	A
C.	Revise Program Management Plan (PMP) (See AFSCP 800-3, Attachments 3 & 4)	Revised PMP	Provide inputs & coordinate on relevant sections: system engineering, test & evaluation, manpower & organization, security, application of directives		R	C	C		G	A	O	A	A	U
D.	Validation Phase contract negotiation	Updated Validation Phase:												
	1. Release Validation Phase RFP	1. RFP, including Model Contract	1. Review & modify software-related system specification, Model Contract, CWBS, & SOW sections, & evaluation criteria			A	A		R	G	P	O	A	U
	2. Form Source Selection organization	2. None specified**	2. Evaluate software-related proposal sections		O	P	A			A	P	G	A	U
	3. Evaluate proposals	3. Proposals including CPDP [E-695/ESD] & any SEMP [S-3618]	3. Review & modify CPDP & any SEMP		O	C	C			A	P		A	U
	4. Negotiate & award contract(s)	4. Contract	4. Review software-related provisions		R	A	A				P	O	A	U

* See KEY on final page.

** "None specified" means that no directive reviewed specifies a particular form for this product. Hence, memoranda or technical reports would be used, as appropriate.

\# Products' DID Numbers are bracketed where first named.

Table 2 (Continued)

SEI	Activity or Event	Product(s)#	Software-Related Effort	Government Roles[a] USD	OSF	OAE	PLR	AFC	ATC	AIC	SCS	PPQ	CCQ	FRC	Type of Contract Support[a]
E.	Develop Allocated Baseline and corresponding higher-level specifications														
	1. Do operational performance tradeoffs vs. system design a. Modify system design concept & system specification accordingly b. Modify performance, cost & schedule estimates	1. Technical Reports [S-3591A]; Technical Performance Measurement Reports [S-3619]	1. Revise system design; re-estimate model performance characteristics; simulate changed designs & analyze results		A	A		R			O		P		B,P,S
	2. Explicitly state, quantify & prioritize all known & expected risks	2. None specified[b]	2. Revise software-related risk assessments		A	A		R	A		O		P		E
	3. Perform design studies, including selected CI design; conduct System Requirements Review & System Design Review	3.-5a. System Requirements Review minutes [E-3118] b. System Design Review C. Authenticated System Specification [E-3101] d. Any Segment Specifications [E-3101]	3. Review software changes to Functional Baseline for consistency, *oversight, & impact*			A					O		P		S
	4. Define equipment CIs & CPCIs		4. Revise software-related material								O		P		B,S
	5. Allocate system performance & design requirements among any Segments & among CIs		5a. Assess feasibility of software performance allocation (e.g., execution time & memory budgets) b. Design critical routines & estimate their performance								O		P		S
	6. Run Feasibility Demonstration (begun in Conceptual Phase) of risky subsystems & components	6a. Technical Reports [S-3591A] b. Demonstration equipment & software [E-129]	6. Investigate software-related problems		R	A					O		P		D,S
	7. Draft Development Specifications for equipment CIs and CPCIs	7. Preliminary CI Development Specifications [E-3102A or E-3119A]	7. Draft or review CPCI Development Specifications		A	A		R	A		O		P		A,B
	8. Draft equipment CI & CPCI Test Plans	8. Preliminary Category I Test Plans [T-3702 or T-3703]	8. Draft or review Preliminary CPCI Test Plans		A	A		R	A		O		P		A,D,E
F.	Plan Full-Scale Development Phase management														
	1. Develop Initial Computer Resources Integrated Support Plan (CRISP)	1. Initial CRISP	1. Draft CRISP		R	R	P			A	O		A		U
	2. Revise contractor plans for Full-Scale Development	2a. Revise CDPD(s) [E-695/ESD] b. Revise SEMP [S-3618]	2. Review CPDP(s) & SEMP and negotiate revisions; address computer program development & maintenance facilities; address phase in/phase over requirements, interoperability, manpower, & schedules								O	C	A		A,E

Table 2 (Continued)

SEI	Activity or Event	Product(s)#	Software-Related Effort	OSD	USAE	OPER	AFLC	ATC	AFSC	ICS	PQ	PCQ	FCRC	Type of Contract Support*
F.	3. Develop integrated plan for system testing	3. Updated TEMP	3. Draft & review software-related sections, including any Independent V&V material			P	A		R	A	O		P	A
	4. Prepare RFP(s) for Full-Scale Development Phase	4. Draft Full-Scale Development Phase RFP	4. Prepare software-related RFP sections & review entire RFP		R	A	A			A	P	O	A	A,E
	5. Update Procurement Plan	5. Updated Procurement Plan	5. Advise PM as requested											
	6. Plan training for subsequent phases in consultation with Air Training Command (ATC)	6. Training Plan	6a. Identify software needing maintenance & use (per draft CRISP) b. Identify required software training facilities & manpower c. Specify types of training required d. Prepare/review training schedules		R	C	P	P		G	O	C	A	A
G.	Prepare for Ratification Decision		Provide, as required, special studies & inputs		R	R	A		A	R	O	A	A	A
	1. Prepare initial draft DCP II, addressing directed topics; e.g.: a. Current threat & operational need b. Other new & changed system functional & performance objectives c. Balance of money cost, schedule & performance goals d. Realism of cost, resource, & schedule estimates, including support & operational requirements e. Appropriate & well-defined cost, schedule, & performance thresholds f. Remaining risk levels, & future risk identification & disposition procedures g. Avoidance of duplication h. Use of existing subsystems i. Integrated test & evaluation planning j. Program management structure, plan, & acquisition strategy	1. Initial draft DCP II												
	2. Assemble backup material	2. E.g., RFP, TEMP									O			

Table 2 (Concluded)

SET	Activity or Event	Product(s)#	Software-Related Effort	Government Roles@ USD SAF OSD PO AFLC AFSC ICS FCRC PCO	Type of Contract Support@
H.	DCP II Review/Approval				
	1. DSARC review, modify & coordinate DCP II	1. "For comment" & "for coordination" DCP II drafts	1. Possible briefing & consultation to DSARC	O A A A A A A	U
	2. Ratification Decision by Secretary of Defense	2a. DCP II signed & perhaps changed b. Possible memorandum of direction	2. None	O	

KEY

Government Participants

OSD = Office of the Secretary of Defense (e.g., Secretary, DSARC)
USAF = Headquarters, USAF (i.e., Secretary or Air Staff)
OPER = Operating Command (e.g., ADCOM, MAC, SAC)
AFLC = Air Force Logistics Command
ATC = Air Training Command
AFSC = Headquarters, Air Force Systems Command
ICS = Intermediate Command (e.g., ESD) Staff
PO = Program Office (including PM)
PCO = Procuring Contracting Officer
FCRC = Federal Contract Research Center (e.g., MITRE)

Typical Government Roles##

A = Advises or submits input
C = Provides comments for coordination
G = provides supplementary guidance
I = Initiates activity
O = Office of primary responsibility
P = Major participant in work
R = Review & decides

Type of Contract Support##

A = Ad hoc informal consultation
B = Basic program or data base design
D = Develop (e.g., design, code, document, test & integrate) CIs
E = Estimate costs, schedule or risks
P = Predict performance
R = Critical review
S = System or Segment design
T = Test & integrate System or Segment
U = Unwise (e.g., illegal, infeasible)

The Government roles and types of contractor support indicated apply to the entire set (e.g., Set A, Set C), or to parts of the set (e.g., A.1), with the description of which they line up.

2-5), calls this the Authenticated System Specification. AFR 800-3, Engineering for Defense Systems (paragraph 4.b) includes the Authenticated System Specification in the Allocated baseline, while other sources exclude it. (See, e.g., MIL-STD-480, paragraph 110.3 and AFSCP 800-3, paragraph 9-9). Given this choice of authorities, this guidebook assumes exclusion of the Authenticated System Specification from the Allocated Baseline, consistent with common usage. However, system development should be based on both the Authenticated System Specification and the Development Specifications, and on any Segment Specifications (see Section 4.3.3), in case of omissions from, or conflict among, the Development Specifications. In such cases the Authenticated System Specification should have highest precedence (see SOWG, Section C2.5.1), on the grounds that system-level requirements are more fundamental than allocated (i.e., derived) requirements.

4.3.1.2 Configuration Item Definition. The number and composition of a system's CIs is a critical design issue, because the Government's technical monitoring activities focus mainly on CIs. For example, each CPCI developed normally requires the developer to prepare an individual Computer Program Product Specification (see Section A4), an individual Test Plan, and related Test Procedures. Each CI usually undergoes individual design reviews. One or more WBS Elements (see SOWG, Appendix A) must also be defined for each CI, for use in cost reporting and analysis.

A system of many CIs has many formally defined interfaces. The separate reports, other documents, and other monitoring activities required can support good Government visibility into, and control of, the development process.

However, if a system is partitioned into too many CIs, the large number of document review, Engineering Change Proposal (ECP) processing, and other monitoring activities entailed may fragment insight and cause excessive delays, significantly impeding development progress. Independent or sequential Government monitoring of individual CIs may partly ignore the needs of closely related CIs, so that decisions made about one CI may adversely affect another. Conducting joint design reviews for the members of each closely related set of CIs, and employing the same Government personnel to monitor all the set's members, can improve overall visibility. Nevertheless, even thorough design review rarely prevents subsequent discovery of some necessary changes in CI scope or external CI interfaces. Such changes require formal ECP preparation and Configuration Control Board (CCB) action during development, activities that typically consume weeks or months. Largely because of its greater quantity of baselined information (e.g., inter-CI interface definitions in Development Specifications), a multi-CI system may require more ECPs during its development than a system of fewer CIs. Similarly, the effort needed to review and coordinate revisions to Product Specifications, Test Plans, Test Procedures and other required documents depends significantly on the number of documents reviewed as well as on the scope of each. Like ECP processing, document review can entail long elapsed times, because comments must typically be solicited from many reviewers, formally coordinated, and reflected in one or more revisions before approval. Thus, a multi-CI system's development may suffer more delay from Government monitoring activities than a system of fewer CIs.

Somewhat different problems can arise if a system's CIs are few, but ill-defined. This situation exists to the extent that one CI contains processes that interact more strongly with other CIs than with one another. A system of ill-defined CIs is most likely when CI definition occurs hastily without adequate preliminary design and design validation (see Section 4.3.2). Here the inter-CI interfaces, although few, are complex. As a result, the larger scope of the individual CI design reviews will still fail to spot many inconsistencies among CIs. Also, the complex internal workings of large, ill-defined CIs discourages learning and discovery of internal flaws. Both factors encourage overlooked design errors during document study and design reviews. These oversights lead later to many ECPs and to progressively more expensive repairs, depending on when each error is detected.

We know of no well-defined procedure to specify an optimum set of CIs. However, the guidelines stated below should help define a good set of CPCIs, although they are incomplete.

a. Assign processes that interact strongly (e.g., in many or complex ways) to the same CPCI.

b. Assign processes that have little or no interaction to different CPCIs.

c. Allocate to different CPCIs processes that will execute in different computers.

d. Assign to different CPCIs processes whose development can feasibly be finished at significantly different times, if such phased development will expedite overall system development.

e. Allocate to different CPCIs software to be procured separately.

f. Include in each CPCI no more than a small, well-knit group of Government monitors can efficiently track, assuming reasonable working relationships between them and the types of personnel who will manage and develop the CPCI.

It should be clear that applying these guidelines entails considerable preliminary design and analysis. Guidelines a, b, d, and f also apply to equipment CIs, as does guideline e if "equipment" is substituted for "software".

Even when a system has many small CIs, WBS definition must generally extend below the CI level, to the CPC or major routine level, in order to yield data adequate for both thorough contractor performance monitoring and to sound future software cost estimation. Such detailing of WBS Elements below the CI level is best done by the development organization, with Program Office concurrence. (See SOWG, Appendix A for explanation of WBSs). Such WBS Element breakdown should be done as the detailed design of each CI unfolds, and incorporated in the Extended Contract WBS (see SOWG, Section A4.6).

4.3.1.3 Common System Definition Errors. One common error in system definition is failure to specify as CPCIs certain essential Support Software (e.g., Executive, equipment and software diagnostics, software development and maintenance aids, test drivers, test data generators, data collection and data reduction programs)*. As a result, the Government may lack normal control of and visibility into this software's functional & design characteristics, and may even lack the right to use the software throughout the system's lifetime. Such rights of control, visibility and permanent use can be critical; e.g., to validating test results, to testing Deployment Phase software modifications. If use of proprietary Operational or Support Software is planned, the CPDP (see Section 4.4.5) should detail its use in the system. Furthermore, the appropriate contract should specifically provide for delivery of that proprietary software with satisfactory documentation and rights of duplication & use (see SOWG, Section C2.5.4).

Another common error is failure to prescribe precisely the system's interfaces with its operators (e.g., terminal users). These interfaces should be considered requirements, not design options, because a good man-machine interface is quite heavily influenced by detailed operational requirements.

Special problems may arise when use is planned of existing software (e.g., the Executive, a compiler, diagnostics) that was developed, perhaps for commercial use, independent of standard Air Force configuration control, testing and documentation practices. Although incorporating such software, where appropriate, may save significant development time and cost, this software or its documentation may be somewhat deficient for the intended Air Force application. Thus, during the Validation Phase, all such existing software should be tested, and its documentation reviewed, against system requirements. Plans should then be made to upgrade or augment this software and its documentation during the Full-Scale Development Phase, to correct deficiencies. For example, if use of a commercially available Executive is planned, this Executive should be allocated functional, design, interface, performance and test requirements. The Executive should then be tested for ability to satisfy all its allocated requirements. Again, the Executive's documentation should be reviewed against the needs of the planned Air Force system's operators, development programmers, and maintenance programmers to assure its satisfactory organization and content. Existing commercial documentation need not conform precisely to Air Force documentation standards (e.g., for Type B5 and Type C5 specifications per MIL-STD-490 and MIL-STD-483(USAF)). However, these standards should be reviewed for factors appropriate to judging existing documentation against expected needs. Note that the Government may need to acquire Limited Rights to this existing software, and Restricted Rights to its documentation (see SOWG, Section C2.5.4) in order to use or upgrade them.

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* SOWG, Table A-3 identifies many such types of Support Software. The Software Acquisition Management Guidebook: Software Development and Maintenance Facilities discusses typical support software and its uses.

4.3.2 System Design Validation

The Validation Phase is intended to develop a low-risk system design clearly able to meet the requirements of the System Specification, within the cost and schedule thresholds established by the approved version of DCP I. Attaining this goal will usually require the definition, partial development, and evaluation of several alternate designs. A typical Major Defense System's complexity makes very difficult the accurate evaluation of a design alternative, especially its workload-handling capacity and achievable response times, which often defy precise mathematical analysis. If, as is usual, essentially complete prototypes of the system alternatives are unavailable for instrumentation, discrete event simulation of the system alternatives offers the best chance of developing sound performance prediction data, if based on well understood requirements, sound analytic technique, and realistic estimates of workload, component size, and component performance. Thus, the simulation computer programs developed during the Conceptual Phase (see Table 1, Set J) should be refined and used during the Validation Phase to help evaluate the design alternatives. If not yet available, these programs should be developed during the Validation Phase.

A system design can seldom be validated unless first developed in considerable detail. For example, to show that a proposed system will accept and process a particular type of input, and produce expected output, within prescribed response time limits, typically involves estimating and summing the processing times of, and the expected queuing delays at, each system component that handles these outputs and their precursors. Considerable detailed computer program design, sizing, estimation of routines' execution times, and subsequent simulation may be essential to obtain credible estimates of the corresponding processing and queue-residence times. The CPCs of CPCIs that implement time-consuming algorithms are prime candidates for such design, sizing, estimation, and simulation.

Whenever properly conducted system design validation results in selection of a preferred design shown able to meet the system's requirements, this design should <u>not</u> be discarded. Developing and validating such a design requires extensive effort during the Validation Phase, which Offerers for Full-Scale Development Phase contracts are unlikely to duplicate. Especially if the Government's preferred design resulted from an open design competition, there is little chance that a Full-Scale Development Phase Offerer will suggest a better design, and considerable risk that this design would fail thorough validation. Instead, the Government's validated design should be incorporated in the appropriate CI Development Specifications. These specifications should include all design requirements and other assumptions employed in validating the design. However, unvalidated design detail should be omitted to avoid unnecessarily constraining Offerers' design freedom, and also because it may be wrong!

Subsequently, the Government may let Offerers for Full-Scale Development Phase contracts propose design modifications. However, this approach should be followed only if the Government expects a substantially improved design to result, and if time and other resources permit proper evaluation of the proposed design modifications. If proposing design changes

is allowed, each Offerer should be required to submit all evidence necessary for Government validation that his proposed design will satisfy the system requirements better than the Government-specified design. The Government has no obligation to accept a proposed design. Indeed, unless an Offerer can prove that his proposed system design changes can better meet the system's requirements, the Government should not accept the proposed changes, during or after contract negotiations. Any acceptable proof should meet the same standards used to select the Allocated Baseline developed during the Validation Phase.

Some consider imposing a validated design on a contractor unsound because it would limit his design freedom and might thus preclude a better system design. However, proper design validation will yield a sound, low-risk design, while the risk of unsuccessful development based on an unvalidated design is much greater. Considering the usually severe adverse affects of unsuccessful system development, it will rarely pay to select a high-risk design over a validated low-risk design.

Others maintain that imposing a design, validated or not, eliminates contractor responsibility for developing a defective system. This need not be true. A contractor who signs a properly worded contract accepts legal liability for developing a system that meets its specified performance requirements subject to its specified design constraints. More important, regardless of legal liability, the Government retains the main risks associated with development of a Major Defense System. These include the practical difficulties of recovering sunk development costs, the high costs of system modification (or redevelopment), and the operational impact of late delivery and reduced system capability. The Government should thus insist on a properly validated design to reduce such risks.

Demonstration of feasibility should include building and evaluating experimental equipment and software for any parts of the system deemed especially critical or risky during Conceptual Phase analyses. Evaluation of this software and equipment should assess both design and performance, and results should be factored into other Validation Phase effort (e.g., simulation). Equipment evaluation should also encompass reliability, maintainability and producibility. Note that evaluating this equipment and software may both entail developing automated evaluation aids. Such aids include software to generate and present test data, to trace execution sequences, to help measure elapsed times, to record results, and to control test sequencing. Developing experimental equipment and software and their evaluation aids should start during the Conceptual Phase (see Table 1, Set G), because of long lead times. The magnitude of the effort necessary may require contractor support.

4.3.3 System Segment Definition

As the Allocated Baseline evolves, it may seem desirable to divide the system into two or more major parts for development by separate organizations during the Full-Scale Development Phase. Each such part, which MIL-STD-483(USAF) (paragraph 30.6.2) terms a System Segment (or Segment for short), consists of one or more complete Functional Areas and usually includes

several CIs. One possible good reason to segment a system is that essential expertise applicable to different parts of the system may be split among different potential contractors. For example, a separate Software Segment might be defined to encourage participation in the system development by software development firms better qualified than general system contractors to produce critical software.

However, segmentation introduces an additional configuration management level between the system level and the CI level. Thus, segmentation increases the complexity of system management, introduces additional costs, and may cause more problems than it resolves. For example, each Segment must be allocated a subset of the system's requirements, including test requirements. Once contractually defined, such allocations are hard to change, and if not well conceived can cause severe performance problems or disputes about responsibilities. MIL-STD-483(USAF) (paragraph 30.6), requires Segment Specifications (see Section A2) in some cases. If so they must be prepared and reviewed. Per MIL-STD-483(USAF), paragraph 20, intersegment interfaces must be defined in Interface Control Drawings (ICDs), and an Interface Control Working Group (ICWG) must be established to adjudicate disputes and changes related to interfaces between Segments. ICD revisions, typically Engineering Change Orders (ECOs), must be approved by the ICWG. If ICWG actions are not closely coordinated with CCB actions, they may cause inconsistencies in the system baseline. Similarly, the CCB evaluation of an ECP may involve several contractors and require coordination with the ICWG. Segment-level requirements reviews, design reviews and tests must be planned, and these activities must be monitored. The Segment Tests, the ICWG, the ICDs and Segment Specifications are not required if a system is not segmented.

4.4 Validation Phase Planning Activities

Refer to Table 2, Sets C, D, F & G. As discussed subsequently, several versions of some of the plans mentioned (e.g., the PMP) may be prepared in different Acquisition Life Cycle phases, or a plan's development may sometimes begin in the Conceptual Phase. Despite these variations, preparation of these plans are most appropriately discussed as Validation Phase activities.

To encourage alternative designs and sound analysis, two or more parallel Validation Phase contracts may be let for system (or Segment) design, analysis, and planning for subsequent Acquisition Life Cycle phases. The stimulus of competition is a major aim of this approach. Hence, provision should be made to award the winning Validation Phase contractor(s) major development roles during the Full-Scale Development Phase, provided a favorable Ratification Decision is made. Contractor selection for Full-Scale Development Phase work will depend primarily on the competitors' cost and schedule estimates and on Government assessment of their management skills, as well as on the proposals' technical merit. Under these circumstances, each Validation Phase RFP (i.e., one per planned contract) should prescribe preparation and delivery of a draft CPDP and (if the contract involves System Engineering effort) a SEMP, for the Full-Scale Development Phase. During Validation Phase Source Selection (Set D), Government personnel must review

the version of each such plan produced by each prospective contractor or Government development organization.

Besides Validation Phase RFP review, and Validation Phase Source Selection, the other chief management-oriented Validation Phase activities to be performed by Government personnel include:

a. revising the Program Management Plan (PMP), first prepared during the Conceptual Phase, to reflect guidance in PMD and AFSC Form 56 supplements;

b. developing a first version of the Computer Resources Integrated Support Plan (CRISP);

c. writing a Test and Evaluation Master Plan (TEMP);

d. drafting a Training Plan; and

e. preparing the initial draft DCP II and related backup material.

In addition, Government personnel must produce the draft RFP(s) for the Full-Scale Development Phase contract(s). The RFP for each contract involving System Engineering effort should require a SEMP, and the RFP for each contract involving software development should require a CPDP, for the reasons stated in the previous paragraph about competitive Validation Phase RFPs.

4.4.1 The Program Management Plan (PMP)

AFR 800-2 prescribes the PMP. AFSCP 800-3 (especially Attachments 3 & 4) further defines it. Basically, the PMP must describe the system to be acquired, identify available resources, define the overall acquisition management approach, identify the participating Government organizations, and specify their roles. Topics to be addressed include: Program Summary & Authorization, Intelligence, Program Management, System Engineering, Test & Evaluation, Communications/Electronics, Operations, Civil Engineering, Logistics, Manpower & Organization, Personnel Training, Security, and Directives Application. The PMP, prepared by the Program Office, requires coordination by all participating commands. An initial version of the PMP is normally prepared in response to the Conceptual Phase PMD. This must be revised to reflect supplementary direction. Major revision in response to Validation Phase PMD and AFSC Form 56 direction should be expected.

4.4.2 The Computer Resources Integrated Support Plan (CRISP)

Prescribed by AFR 800-14, Vol. II, for acquisitions that involve Computer Resources (i.e., computer equipment, software, related documentation, and associated personnel), the CRISP is intended to clarify the software-related roles of the Government participants in a system's development. The CRISP

"identifies organizational relationships and responsibilities for the management and technical support of computer resources. It functions during the full-scale development phase to identify computer resources necessary to support computer programs after transfer of program management responsibility and system turnover."*

AFR 800-14, Vol. II (paragraph 3-10) directs formation of a Computer Resources Working Group (CRWG), chaired by the Program Office until Program Management Responsibility Transfer (PMRT) and System/Equipment Turnover (see Section 6.4). The CRWG is responsible for initial development and subsequent updating of tne CRISP. Although not required, development during the Conceptual Phase of the portions of the initial CRISP that reflect the Government participants' overall roles and missions could aid system planning.

4.4.3 The Test and Evaluation Master Plan (TEMP)

Per AFR 800-14, Vol. II (paragraphs 5-2 and 5-5), the TEMP is intended to supplement the PMP and the Test & Evaluation Objectives Annex (TEOA) of the PMD. Per AFR 80-14, Test and Evaluation, AFSC Supplement 1 (paragraph 20e), the TEMP is intended to

"document a coordinated position for all the participants in the T&E of a particular program, and give decision makers an opportunity to examine the plan for accomplishing T&E".

TEMP development is a Program Office responsibility, but the Operating Command and Supporting Command, plus any other agencies involved in the system's Test and Evaluation (T&E) must coordinate on it. The TEMP must address:

a. critical questions and areas of risk;

b. test objectives;

c. the T&E program outline;

d. responsibilities of all participants, including contractors;

e. test costs and schedules; and

g. needed test resources (e.g., instrumentation, other equipment, facilities, data).

AFSC Supplement 1 excludes Follow-on Operational T&E (FOT&E) from the TEMP's scope. AFR 80-14 does not. They agree that the TEMP must encompass Development Test & Evaluation (DT&E) and Initial Operational Test & Evaluation (IOT&E). DT&E, an Implementing Command responsibility, includes all formal CPCI testing (e.g., all Formal Qualification Tests (FQT)), Segment testing (if any), and system-level testing against System Specification

* AFR 800-14, Vol. II, paragraph 3-8.

requirements. Operational Test and Evaluation (OT&E) (i.e., IOT&E + FOT&E) is intended mainly to assess a Major Defense System's operational utility, in contrast to its formal compliance with specifications. OT&E is normally the responsibility of the Using Command, or of the Air Force Test and Evaluation Center (AFTEC), with assistance from the Implementing Command and the Supporting Command (usually the Air Force Logistics Command (AFLC)).

Per AFR 80-14 (paragraph 20e) the TEMP must be prepared "as early as possible...prior to initiation of full-scale development." Normally the TEMP will be prepared early in the Validation Phase, but under some circumstances could be drafted earlier. The TEMP must be updated to reflect each significant change in the test program.

4.4.4 The Training Plan

Per AFSCP 800-3 (paragraph 3), the Training Plan is intended to establish requirements for training Air Force personnel in the operation and maintenance of the system, beginning during Full-Scale Development. Training Plan preparation entails active participation by Implementing Command, Using Command, Supporting Command, and Air Training Command (ATC) personnel.

4.4.5 The Computer Program Development Plan (CPDP)

AFR 800-14, Vol. II (paragraphs 3-5 and 3-9), requires a CPDP for every Major Defense System acquisition that includes software development, and prescribes CPDP contents. In part, the CPDP must state: the organization and responsibilities of the software development group(s); the skill level of the software design, development & maintenance personnel; software management and technical control methods; software Quality Assurance (QA) methodology; software development schedule and milestones; configuration control and status monitoring procedures; documentation and training methods; and programming standards. CPDP preparation is an Implementing Command responsibility. However, each of tne Offerers for a software development contract (and each of any prospective Government software development organizations) should be required to prepare a CPDP as part of its proposal; a CPDP will provide important evidence of its Offerer's competence. Such a CPDP should be prepared regardless of Acquisition Life Cycle phase. For example, a RFP issued during the Conceptual Phase that calls for extensive software development should require each Offerer to submit a CPDP as part of his proposal. After modification during negotiation of contracts (or interagency memoranda of agreement) the CPDP of each selected contractor or Government development organization should become part of its agreement with the Implementing Command, so that its provisions can be enforced. The CPDP will probably require updating during development; e.g., to reflect schedule changes. Thus, a SOW task should provide for such updating.

4.4.6 The System Engineering Management Plan (SEMP)

MIL-STD-499A, Engineering Management, and AFR 800-3, define Systems Engineering, and prescribe the Systems Engineering effort needed during the acquisition of Major Defense Systems. They require the development

of a three-part SEMP and prescribe its contents*. If a planned contract is to include Systems Engineering effort, the RFP for that contract should require a SEMP as part of each Offerer's proposal, to become binding (after possible negotiated change) upon contract award.** A SOW task should provide for the SEMP's subsequent updating.

4.5 Termination

Refer Table 2, Set H. A second DSARC review and the Ratification Decision are prescribed to terminate the Validation Phase, in order to judge the adequacy of its results and to reassess the continued importance of developing the planned system. An adverse Ratification Decision, which would cause program termination, could result from any of the following:

a. inadequate Validation Phase products;

b. detection of severe and evidently insurmountable technical problems during the Validation Phase;

c. excessively escalating costs; or

d. sufficient reduction in the operational need for the planned system.

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* MIL-STD-499A, paragraph 5.1.

** AFR 800-3, paragraph 4.c.

5. FULL-SCALE DEVELOPMENT PHASE

5.1 Objectives

The Full-Scale Development Phase is intended to yield:

a. a working prototype of the Major Defense System (or the system, if there are to be no replicas);

b. test results proving that this prototype can meet its functional and performance requirements;

c. a cadre trained in the system's operation and maintenance; and

d. the documentation needed to begin the system's Production Phase (if any), or otherwise needed for its Deployment Phase.

These objectives entail completing the system's engineering design; resolving all major uncertainties, outstanding issues, and other problems; and thoroughly testing the functions and performance of the prototype system and its components. Note that for the system's software, the Full-Scale Development Phase is intended to yield the initial operational versions of the Computer Programs, not prototypes. "Prototype" is properly applied to preproduction equipment whose form, fit and function will be identical to those of the (multiple) production units planned, but which may differ from the production units in other ways.

5.2 Initiating Events

See Table 3, Set A. A favorable Ratification Decision by the Secretary of Defense begins the Full-Scale Development Phase. The Ratification Decision may prescribe redirection of certain system goals, schedules, allowable costs, and other constraints. Both Headquarters, USAF, and AFSC may issue supplementary guidance. All are then to be reflected in a revised PMD.*

5.3 Other Activities and Related Products

See Table 3, Sets B through G. Full-Scale Development Phase work is treated less fully than the Conceptual Phase and Validation Phase activities, discussed in Sections 3 and 4, because model Full-Scale Development Phase SOW paragraphs and commentary on them are included in the SOW guidebook. However, several major points about certain Full-Scale Development Phase activities and products should be noted.

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* AFR 70-15, paragraph 2-1b.

Table 3

Major Full-Scale Development Phase Activities

SET	Activity or Event	Product(s)#	Software-Related Effort	Government Roles* OSD	USAF	OAE	AFSC	AFLC	AFTC	FAA	PCO	FAA	PCO	CRO	Type of Contract Support*
A.	Issue directives & guidance for Full-Scale Development Phase														
	1. Provide guidance	1. Modified DCP II & PMD; any memoranda of direction	1. None	O	P			G							U
	2. Release program funds	2. BA/PA	2. None		O			G							U
	3. Confirm program priorities	3. None specified**	3. None					O							U
B.	Select Full-Scale Development Phase contractor(s)														
	1. Complete & issue Full-Scale Development Phase RFP(s)	1. RFP(s) for Full-Scale Development Phase	1. Revise/review software-related RFP material; e.g., SOW sections		R	C	C	A	G	G	P	O	P		U
	2. Review proposals & negotiate contract(s)	2. Signed contract(s) with one or more suppliers	2. For each proposal: a. Review software-related sections *b. Analyze soundness of approaches* c. Assess cost & schedule realism		R	P	P	A	G	G	P	O	A		U
C.	Revise acquisition & management plans to reflect guidance & contract provisions														
		1. Revised PMP	1. Review software-related changes		R	C	C	C	G	A	O	A	A		U
		2. Revised CRISP	2. Revise CRISP		R	P	P	C	G	A	O		A		U
		3. Revised CPDP [E-695/ESD] if not a contract deliverable	3. Review/revise CPDP if not contractor-provided		R	C	C	C	G	A	O	A	A		U
		4. Revised Procurement Plan	4. Review need for Independent V&V		R	C	C		G	G	O	G			A
		5. Revised Training Plan	5. Review for software impact		R	C	C	C	G	A	O		A		U
D.	Revise Allocated Baseline to reflect guidance & contractual agreements														
	1. Alter System Specification to include changes: a. System performance & design requirements	1. Revised Authenticated System Specification [E-3101]	1. See Table 2, Set E		R	C	C		R	A	O	R	A		B,P,R,S

* See Key on final page.

** "None specified" means that no directive reviewed specifies a particular form for this product. Hence, memoranda or technical reports should be used as appropriate.

\# Products' DID numbers are bracketed when first named.

Table 3 (Continued)

SET	Activity or Event	Product(s)#	Software-Related Effort	Government Roles* USD	OSF	OAE RCL	AFC TCC	AIC SCS	PCQ QQ	FCR EC	Type of Contract Support*
D.	1. b. CI breakdown c. Allocation of requirements to CIs d. Testing requirements	See above	See above	S	E	E		A	B	O V E	
	2. Change costs & schedules to reflect agreements	2. None specified**	2. Revise software-related cost & schedule estimates	R	C	C	R	A	O	R A E	
E.	Complete definition & design of system components										
	1. For each CI: a. Spell out internal interface requirements b. Complete & approve Development Specification (for an equipment CI) or Computer Program Development Specification (for a CPCI)	1. For each CI: a-b. Baselined Development Specification [E-3102A] or Computer Program Development Specification [E-3119A]	1. For each CPCI or related equipment CI: a-e. Prepare, revise, or review drafts of identified products		A	A		R		A	B,D,P
	c. Complete & approve test plan & test procedures	c. Approved Category I Test Plan/Procedures [T-3702 or T-3703]									
	d. Design in detail	d. Initial Draft Product Specification [E-3103A] or Computer Program Product Specification [E-3120A]									
	e. Revise space & execution time estimates	e. Technical Performance Measurement Reports [S-3619]									
	f. Conduct Preliminary Design Review (PDR)	f. PDR minutes [E-3118] & action item responses	f. Attend PDR; track & review minutes & action item responses								
	2. For system as a whole: a. Monitor design activity	2. For system as a whole: a. None specified**	2. For system as a whole: a. Attend CI PDRs & any follow-up SDR sessions		P	P	P	O		P	P,R,S
	b. Begin to develop & maintain system-level design documentation	b. E.g., flow diagrams of messages & other transactions through the system in Subsystem Design Analysis Report [S-3681] (for whole system)	b. Prepare & review software input to system-level software design documentation		A	A		O		P	P,S

Table 3 (Continued)

SEI	Activity or Event	Product(s)#	Software-Related Effort	Government Roles*									Type of Contract Support*
				USD	OSF	APER	AFLC	ATCC	AFCS	ICSP	PPQO	PCRC	FCC	
E. 2. c.	Surface, investigate & resolve inconsistencies & omissions (interface problems) among CIs, and between system & its environment	c. E.g.; Interface Control Drawings; Technical Reports [S-3591A]	c. Cross-check CPCI specifications, software-related CI specifications, the System Specification, & related design documentation in search of interface problems								R		P	R,S,T
	d. Filter requested computer resource allocation changes (e.g., to memory & execution time allowed)	d. None specified**	d. Verify need for requested increases in resource allocations; investigate more economical algorithms & coding to mitigate increases								O		R	E,P,R,S
	e. Filter requested changes to baselined System & Development specifications	e. Engineering Change Proposals [E-3128] & Specification Change Notices [E-3134]	e. Assess design & resource impacts of proposed changes			A	A				O		P	B,E,P,S
	f. Modify system models to reflect revised CI execution time & space estimates	f. New system simulation program Versions [E-129] & Version Description Documents [E-3121]	f. Re-estimate module performance characteristics								O		P	B,P,R,S
	g. Run simulation program & analyze results to update & improve performance	g. Technical reports [S-3591A]; Technical Performance Measurement Reports [S-3619]	g. Simulate changed design & analyze results								O		P	B,P,R,S
	h. Plan system-level Development Test & Evaluation (DT&E)	h-i. System Test Plan [T-3701]; Category II Test Plan/Procedures [T-3706]	h-i. Prepare & review software-related provisions of system-level Test Plan/Procedures; update these to reflect ECPs; define, design & develop automated aids to system-level testing			C	C	C			O		P	B,D,S,T
	i. Plan Initial Operational Test & Evaluation (IOT&E)													
	j. Plan Follow-on Operational Test & Evaluation (FOT&E)	j. None specified**	j. Essentially the same is "i"			O	C	C			A		A	T
F.	Develop prototype system													
1.	For each CI:	1. For each CI:	1. For each CPCI:											
	a. Conduct Critical Design Review (CDR)	a. CDR minutes [E-3118] & action item responses	a. Compose CDR briefing material, attend CDR & execute appropriate action-item defined tasks			A	A				O		P	B,D
	b. Build prototype equipment; code CPCI	b. Prototype equipment, or computer instructions/data in machine-readable form [E-129]	b. Code & partially debug CPCI								R		R	B,D
	c. Do Preliminary Qualification Testing (PQT)	c-d. Test Reports [T-3717 & T-3718]	c-d. Test & debug CPCI vs. approved test procedures; draft or review Test Reports			A	A				R		R	D
	d. Conduct Formal Qualification Testing (FQT)													
	e. Complete & review draft Product Specification	e. Draft Product Specification [E-3103A or E-3120A]	e. Write or review CPCI Product Specification			A	A				R		R	D

Table 3 (Continued)

SET / Activity or Event	Product(s)#	Software-Related Effort	O S D	U S A F	O P E R	A F L C	A T C	A F S C	I C S	P O	P C O	F C R C	Type of Contract Support*
			Government Roles*										
F. 1. f. Conduct Functional Configuration Audit (FCA)	f. FCA minutes [E-3118] & action item responses	f. Draft or review CPCI FCA minutes; do appropriate action-item prescribed tasks		C	C	C				O		R	D
g. Prepare & approve final version of Product Specification	g. Approved Product Specification [E-3101A or E-3120A]	g. Modify & approve Computer Program Product Specification		C	C					R		R	D
h. Prepare user-oriented documentation (if appropriate)	h. Approved Users' Manual (Computer Program) [M-3410]; Approved Computer Programming Manual [M-3411]	h. Prepare/review/approve user-oriented documentation		C	C		A			R		R	D
i. Conduct Physical Configuration Audit (PCA)	i. PCA minutes [E-3118]	i. Draft or review CPCI PCA minutes; do appropriate action-item prescribed tasks		C	C	C				O		R	D
2. For system as a whole: a. Develop DT&E system test procedures	2. For system as a whole: a. Category II Test Plans/ Procedures [T-3706]	2. For system as a whole: a. Draft/review software-related system test procedures		A	A	A				R		R	S,T
b. Conduct follow-up SDR sessions	b. SDR minutes [E-3118]	b. Draft or review follow-up SDR minutes; do appropriate action-item prescribed tasks		C	C	C				O		R	S
c. Integrate CIs d. Perform system level DT&E	c-d. Test Reports [T-3717 & T-3718]; revised ICDs; changed Product Specifications [E-3103A or E-3120A]	c-d. Observe CPCI/CPCI & CPCI/equipment CI integration tests; investigate incompatabilities; specify changes to equipment CIs & CPCIs to fix problems; specify & observe retesting to verify correction	R	A	A	A				O		R	S,T
e. Perform IOT&E	e. IOT&E reports; revised design documentation	e. Observe tests & fix problems	R	O	A	A				A		A	S,T
f. Write Positional Handbooks	f. Positional Handbooks [M-3409]	f. Prepare/review/approve Positional Handbooks		R	R	R				R		R	D
g. Update system-level design documentation	g. See Set E.2.b	g. See Set E.2.b		A	A					O		P	P,S
G. Prepare for Review Decision 1. If necessary, update Product Baseline (i.e., complete set of approved & consistent CI Product Specifications)	1. a. Product Specifications [E-3103A & E-3120A] b. Specification Change Notices (SCNs) [E-3134]	1. See Set E.2.e	R	A	A					A	O	P	B,D,S,T
2. Update related user-oriented documentation	2. Revised Users' Manuals (Computer Program), Computer Programming Manuals, & Positional Handbooks [M-3410, M-3411 & M-3409]	2. See Set F.1.i. & F.2.e. above		C	C	A				O		R	D

Table 3 (Continued)

SEI	Activity or Event	Product(s)#	Software-Related Effort	Government Roles*										Type of Contract Support*
				USD	OSF	APR	FAC	ALC	ATC	ISC	PSO	PQO	FCC	
G.	3. Plan for PMRT & Turnover	3. Plans for PMRT & Turnover a. PMRT Plan b. System/equipment turnover agreement c. Revised CMSP	3. Consultation to Program Manager		R	C	C		C		A	O		A	U
	4. Prepare initial draft DCP III, usually addressing a. Continuance of operational need b. Progress toward performance objectives c. System suitability, producibility, & operational supportability d. DT&E results & significance e. Scope & schedule of planned remaining tests f. Production/Deployment Phase procurement & Integrated Logistic Support plans g. Results of revised cost, performance & schedule tradeoffs h. Evidence for elimination or tight control of remaining risks	4. Initial Draft DCP III	4. Provide special studies & inputs as required	O	R	G	A	A	G	A	O	A	A	S
H.	DCP III Review/Approval 1. DSARC review, change & coordination of DCP III 2. Review Decision by Secretary of Defense	1. "For comment" & "for coordination" DCP III drafts 2. a. DCP III signed & perhaps changed b. Possible memorandum of direction	1. Possible briefing & consultation to DSARC 2. None	O	G	A	A	A	G	A	A	A	A	U

Table 3 (Concluded)

KEY

Government Participants	Typical Government Roles##	Type of Contract Support##
OSD = Office of the Secretary of Defense (e.g., Secretary, DSARC)	A = Advises or submits input	A = Ad hoc informal consultation
USAF = Headquarters, USAF (i.e., Secretary or Air Staff)	C = Provides comments for coordination	B = Basic program or data base design
OPER = Operating Command (e.g., ADCOM, MAC, SAC)	G = Provides supplementary guidance	D = Develop (e.g., design, code, document, test, & integrate) CIs
AFLC = Air Force Logistics Command	I = Initiates activity	E = Estimate costs, schedule & risks
ATC = Air Training Command	O = Office of primary responsibility	P = Predict performance
AFSC = Headquarters, Air Force Systems Command	P = Major participant in work	R = Critical Review
ICS = Intermediate Command (e.g., ESD) Staff	R = Reviews & decides	S = System or Segment design
PO = Program Office (including PM)		T = Test & integrate system or Segment
PCO = Procuring Contracting Officer		U = Unwise (e.g., illegal, infeasible)
FCRC = Federal Contract Research Center (e.g., MITRE)		

The Government roles and types of contract support indicated apply to the entire set (e.g., Set A, Set C), or to the parts of the set (e.g., F.1.e), with the description of which they line up.

First, Table 3, Set B, assumes that Full-Scale Development Phase RFP issuance, Source Selection, and contract award will occur early in the Full-Scale Development Phase, per planning, development work allocation, and Full-Scale Development Phase SOW draft preparation during the Validation Phase. However, contracts negotiated for Validation Phase work might instead also provide for Full-Scale Development Phase effort, at the Government's option. This alternative contractual approach could eliminate the costs and delay of separate Full-Scale Development Phase Source Selection, provided no drastic changes to the defined Validation Phase contract options were necessary when Full-Scale Development began. Instead of a new Source Selection, the acceptable and necessary contract changes could be implemented in Supplemental Agreements (SAs). This approach would also facilitate selection (for Full-Scale Development Phase work) of any Validation Phase competition winner(s).

Second, significant changes and further detailing of both management plans and system design normally result from Validation Phase work. (See Table 3, Sets C, D, and E). For example, preliminary CPCI Test Plans prepared during the Validation Phase may require revision as a result of Full-Scale Development Phase contract negotiations. Each Full-Scale Development Phase contract (new or SA) should incorporate the appropriate changes in the form of a revised Allocated Baseline, any appropriate Segment Specification, an Authenticated System Specification, SOW provisions, and related CDRL entries.

Third, the system's Operational Software (i.e., the Executive(s) and the Application Programs necessary to meet the system's operational requirements), plus the Support Software necessary to build and maintain the Operational Software and to support DT&E and IOT&E, must normally all be completed during Full-Scale Development. For both Operational Software and Support Software developed for the system, such completion should include:

a. successful conclusion, for all CPCIs, of Preliminary Design Reviews (PDRs), Critical Design Reviews (CDRs), FQTs, Functional Configuration Audits (FCAs), Physical Configuration Audits (PCAs), and Formal Qualification Reviews (FQRs);*

b. successful incorporation of all CPCI changes necessary to complete satisfactorily all Segment-level and system-level DT&E requirements; and

c. delivery of all approved Computer Program Product Specifications.

In contrast, off-the-shelf software may present special problems. If proprietary software is to be incorporated in the system, the Government should negotiate, for a reasonable price, Restricted Rights to such computer programs and Limited Rights to their documentation (see SCWG, Section C2.5.4).

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* MIL-STD-1521(USAF), Technical Reviews and Audits for Systems, Equipment, and Computer Programs, explains PDR, CDR, FCA, PCA, FQR, SDR, etc. Their application to software acquisition is discussed in ESD-TR-75-85, An Air Force Guide for Monitoring and Reporting Software Development Status.

If these negotiations fail, the Government should buy or build alternative software with satisfactory documentation, or if feasible should contract for such documentation. Again, off-the-shelf software, proprietary or otherwise, may lack adequate documentation. Software Acquisition Management Guidebook: Software Development and Maintenance Facilities explains and illustrates typical problems that can result when Support Software is acquired with inadequate rights or documentation. If so, this documentation should be supplemented or upgraded to support adequately its use and maintenance by Government personnel. If this is infeasible, the Government should acquire alternative software with adequate documentation. Adequate off-the-shelf software need not meet Standard Computer Program Product Specification format requirements (see Section A4), but should contain equivalent information in readily usable forms.

Fourth, preparation and updating of system-level design documentation is assumed to begin early in the Full-Scale Development Phase and to continue at least through system-level DT&E (see Table 3, Sets E.2 and F.2). This documentation should include system-wide equipment and software block diagrams, and overview descriptions, keyed to relevant Engineering Drawings and to paragraphs, figures and tables in the system's Authenticated System Specification, any Segment Specifications, CI Development Specifications, and CI Product Specifications. Although not prescribed by standard Data Item Descriptions, such documentation can significantly help in training new personnel, in detecting incompatibilities among CIs, in defining and evaluating ECPs, in defining system-level test procedures, and in interpreting system-level test results. Also presumed are at least two additional System Design Reviews (SDRs) (see Table 3, Set F.2), conducted: (1) immediately following all CI CDRs; and (2) after all CI FCAs, after all CPCI PCAs, and before system-level DT&E. The first of these additional SDRs should show that the system design, as represented by all the CIs' designs, is complete, consistent, and able to meet all the system specification's requirements. The second additional SDR should show that the system is ready for system-level testing. This SDR should show that the system's CIs, as modified during their development, are complete enough, are consistent enough with one another, and well enough reflect system-level requirements, to assure efficient and successful system-level testing.

Fifth, Government-required Preliminary Qualification Testing (PQT) (Table 3, Set F.1) should be minimized or eliminated. The resources saved might be allocated more efficiently to better FQT.

5.4 Terminating Events

Refer to Table 3, Set H. DSARC review, possible modification, and coordination of DCP III precede the Secretary of Defense's Review Decision, which terminates Full-Scale Development. Like earlier decisions, the Review Decision may terminate the program, may redirect it, or may allow it to proceed as planned into the Production and Deployment Phases. Systems whose equipment requires no replication may skip the Production Phase.

6. PRODUCTION AND DEPLOYMENT PHASES

6.1 Objectives

The prime objective of the Production Phase is to produce and install in good working order all planned replicas of the Major Defense System. The chief goal of the Deployment Phase is to use the system effectively, which entails maintaining it efficiently until it is replaced or legitimately consumed (e.g., during warfare).

6.2 Initiating Events

A favorable Review Decision begins the Production Phase, or the Deployment Phase instead if the Production Phase is skipped. This can happen if there are to be no replicas of the Major Defense System, and if the Full-Scale Development Phase result is operationally acceptable. The Review Decision, which may include redirection (e.g., of quantities, of cost and schedule thresholds), is transmitted via Air Staff and AFSC channels. Supplementary direction (e.g., revised AFSC Budget Authorization/Program Authorization (BA/PA)) may result. PMRT and Turnover, discussed below, separate the Production and Deployment Phases. If there is no Production Phase, PMRT and Turnover normally occur shortly after the Review Decision.

6.3 Other Major Activities and Events

As noted in Section 5.3, all of the Major Defense System's Operational Software and most or all of its Support Software must normally be completed by the end of Full-Scale Development. "Production" of this software typically consists of copying its machine-readable storage media (e.g., magnetic tapes) and of reproducing its documentation, both trivial types of operation. One complication is a possible need to adapt each copy of certain software by introducing and testing site-specific parameters. Proper software design will have minimized the impact of this problem by concentrating such site-peculiar modifications: e.g., in a single computer data base. However, to the extent that Site Adaptation involves developing or maintaining different software Versions, these Versions should be produced for and controlled by a single organization.

Aside from Site Adaptation, software-related Production Phase and Deployment Phase work should be limited mainly to maintenance and modification of already complete software. Although development of some new software for such purposes as FOT&E, exercises, and extensive training may be required, most such software should be developed during the Full-Scale Development Phase, since it must be integrated closely with the Operational Software.

Software maintenance consists of investigating alleged software errors and devising corrections or work-arounds if needed. Software modification involves altering software to support changed operational system requirements, or making desired improvements. Both may involve testing of changes at each site where they are introduced.

Typically, level-of-effort contracts are let for both of these functions, by the Using Command or by the Supporting Command. Also typically, software maintenance and modification are managed quite informally. Instead, it is recommended that software maintenance and modification contracts include SOWs, CDRLs, Delivery Schedules and other provisions that clearly define the appropriate activities, products, Periods of Performance and financial controls, as these are defined for software development. Too informal an arrangement can obscure assessment of progress and value received. Alternatively, Air Force instead of contractor personnel may do some or all of the software maintenance and modification. This approach is termed Organic Maintenance, and the Support Software it requires should be covered by Full-Scale Development Phase SOW provisions.

6.4 Terminating Events

PMRT from the Implementing Command to the Using Command, and Turnover of responsibility for support of the system, equipment and software to the Supporting Command (or to a Using Command/Supporting Command combination) terminate any Production Phase. If no Production Phase is planned, these events occur shortly after a favorable Review Decision. Their occurrence marks the start of the Deployment Phase, which lasts until the Major Defense System is deactivated or replaced.

After PMRT and Turnover the chairmanship and membership of the CRWG (which is responsible for preparation and updating of the CRISP) change, per agreement between the Using Command and the Supporting Command. Normally the Supporting Command then assumes CRWG chairmanship, per AFR 800-14, Vol. II (paragraph 3-10).

7. LESS ELABORATE ACQUISITIONS

Acquisitions that do not satisfy the criteria for Major Defense Systems (stated in Section 2) are classified as Less-Than-Major Systems. These may be managed less elaborately than Major Defense Systems. However, the same "...management principles...are applicable to all programs".* Most systems consisting only of software, and many smaller systems that include both equipment and software, would fail to qualify as Major Defense Systems, at least on grounds of predicted costs. In paragraph 1-6, "Management of Smaller Systems", AFSCP 800-3 treats the major differences. These pertain mainly to the types of organization, levels of review & approval, and documentation required. For example, Less-Than-Major Systems involve neither DCP preparation, DSARC review, nor Secretary of Defense decision-making. This information appears useful, although rather general. AFSCR 70-9, Source Selection Procedures, and AFSCR 80-15, R&D Source Selection Policy and Guidance, provide somewhat more specific information about Source Selection for certain Less-Than-Major Systems. Unfortunately, other more definitive directives are not available, and only general guidance can be given here.

In planning software acquisition for Less-Than-Major Systems, a balance must be struck between the benefits and the high costs of the elaborate contract monitoring methods typically applied in Major Defense System acquisitions. Unless the software is extremely simple, little can be eliminated without risking misunderstood requirements, incorrect operation, and loss of Organic Maintenance capability. Thus, the scope of specifications and users' manuals, and the planning, conduct & reporting of tests, cannot be greatly reduced without serious risk of degraded product quality. However, some of the formal procedures involved in baselining, reviewing and status monitoring offer opportunities for streamlining, providing these controls' basic objectives are not thereby compromised. The success of a more informal approach to software acquisition management may also depend heavily on vesting responsibility for monitoring contractor progress in a few competent and dedicated Government personnel. Such success may also depend on writing contracts to withhold substantial payment until the Government certifies satisfaction with the product.

One reasonable basis for preparation of procurement documents (e.g., a SOW) for Less-Than-Major Systems (including software) development involves using Major Defense System Validation Phase and Full-Scale Development Phase documents as models for analogous Less-Than-Major System contracts, or for Less-Than-Major System contracts that combine Validation Phase & Full-Scale Development Phase work. These models should be tailored to the proposed system's specific needs by eliminating unnecessary functions and scaling down others. For example, a normal set of specifications, Test Plans, Test Procedures, tests, and test reports should probably still be prescribed in a Less-Than-Major System SOW. However, the review cycles applicable to these could be simplified by reducing the size and structure of the Government comment coordination network. Soliciting and reviewing comments from all interested groups, but coordinating only the comments of those legitimately

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* DODI 5000.1, Acquisition of Major Defense Systems, paragraph II.

affected by each document, could substantially reduce the coordination effort typically required. Again, elaborate tasks in the Systems Engineering, Supporting Project Management, Integrated Logistics Support, Human Factors and Operational/Site Activation categories (and their related data requirements) are prime candidates for simplification or elimination.

8.0 THE COMPUTER PROGRAM LIFE CYCLE

AFR 800-14, Vol. II (paragraph 2-8), defines a Computer Program Life Cycle distinct from the Major Defense System Acquisition Life Cycle, and relates the two. The Computer Program Life Cycle consists of six phases. These occur mainly in sequence, but overlap somewhat. These phases are termed: (1) Analysis, (2) Design, (3) Coding and Checkout, (4) Test and Integration, (5) Installation, and (6) Operation and Support. AFR 800-14, Vol. II, also defines the goals of, activities in, and milestones for each phase. Per its paragraph 2-8, the Computer Program Life Cycle occurs separately for each CPCI developed

> "at least once...during the system acquisition life cycle. The activities need not be sequential. Instead, there are potential loops between all the phases."

8.1 Nested Computer Program Life Cycles

A higher-level Computer Program Life Cycle should also be defined for each strongly related set of CPCIs, sometimes termed a Software Subsystem. Note that MIL-STD-480, Appendix E, defines "CI" to mean not only an elementary CI but such a related set of CIs, including a Segment. In contrast, this guidebook limits "CI" to the lowest level aggregate of equipment or software defined for Configuration Management, and uses "Software Subsystem" to mean any group of CPCIs to which a separate Computer Program Life Cycle applies. For example, the Software Subsystem of a large Command, Control and Communications system might include the Operational Software for each Segment (if any), the Operational Software for the entire system, the system simulation software, and the T&E software. Each would comprise one or more CPCIs. The Computer Program Life Cycle of each CPCI that belongs to a Software Subsystem is nested in that Software Subsystem's Computer Program Life Cycle. The term Computer Program is used here to mean either a CPCI or a Software Subsystem.

8.2 Relationship to the Acquisition Life Cycle

Per AFR 800-14, Vol. II (paragraph 2-8), a Computer Program Life Cycle "may span more than one system acquisition life cycle phase, or occur in any one phase." For example, high-level discrete event simulation of system design alternatives, to discern their workload handling capacities and related response times, should begin during the Conceptual Phase and should continue with increasing refinement throughout the Validation Phase and the Full-Scale Development Phase. Similarly, the Computer Program Life Cycle for the T&E software might extend from the Validation Phase into the Deployment Phase.

8.3 Computer Program Life Cycle Events

Table 4 summarizes the main types of activity and product of each Computer Program Life Cycle phase. Table 4 is based mainly on AFR 800-14, Vol. II, paragraphs 2-8 and 5-2 through 5-5. Ambiguities in AFR 800-14, Vol. II have entailed some interpretation, however. E.g., note the allocation of system-level DT&E and IOT&E to the Installation Phase. Also note that some of

the Computer Program Life Cycle activities are rather dependent on, and others relatively independent of, Acquisition Life Cycle events.

Table 4

CHIEF COMPUTER PROGRAM LIFE CYCLE ACTIVITIES AND PRODUCTS

ANALYSIS PHASE

Activity	Product(s)
A. Devise & analyze alternatives for the system, Segment (if any), or any Software Subsystem directly containing the Computer Program.	A.1. Tradeoff study reports. 2. Initial or Authenticated System Specification & Segment Specifications (if any).
B. Allocate requirements to the Computer Program: i.e., Functions. Performance (e.g., response times). Interface (with others). Design constraints (e.g., prescribed algorithms, core & processing time budgets). Testing.	B.1. Authenticated Development Specification for each CPCI. 2. Possible higher-level specification, and ICD, changes. 3. Parts of draft Product Specifications containing design approaches for each CPCI.
C. Conduct PDR(s) for the Computer Program's CPCI(s).	C. PDR minutes and action item responses.

DESIGN PHASE

Activity	Product(s)
A.1. Define algorithms not previously prescribed. 2. Design data storage structures. 3. Define Computer Program logic.	A.1. Functional flowcharts. 2. Detailed flowcharts. 3. Data format descriptions. 4. Descriptions of algorithms not previously prescribed.
B. Allocate Computer Program requirements internally (e.g., to CPCs).	B. Preliminary Product Specifications, including the above.
C. Test Planning.	C.1. System, Segment (if any) and CPCI Test Plans. 2. Preliminary CPCI Test Procedures.
D. CDR(s) for the Computer Program's CPCI(s).	D. CDR minutes & action item responses.

Table 4 (Continued)

CODING AND CHECKOUT PHASE

Activity	Product(s)
A. Coding.	A-B. Code.
B. Limited checkout of compiler or assembly units.	
C. Corresponding logic & data structure revisions.	C. Altered Product Specifications, including compiler/assembly listings.

TEST AND INTEGRATION PHASE

Activity	Product(s)
A. Test planning.	A.1. Final CPCI Test Procedures. 2. Segment (if any) and system-level Test Procedures.
B. Module tests.	B-D.1. Test Reports. 2. Computer Program coding changes.
C. CPCI tests (PQT & FQT).	3. Modified Product Specifications.
D. Software Subsystem integration.	4. Possible high-level specification, and ICD, changes.

INSTALLATION PHASE

Activity	Product(s)
A.1. DT&E of any Segments. 2. System-level DT&E.	A.1. Segment (if any) Test Reports. 2. System-level DT&E Test Reports. 3. Computer Program coding changes. 4. Modified Product Specifications. 5. Possible higher-level specification, and ICD changes.
B. Site Adaptation (if any).	B.1. Possible site-specific coding changes. If so; 2. Version Description Documents & 3. Test Reports.
C. IOT&E.	C. IOT&E Test Reports.

Table 4 (Concluded)

OPERATION AND SUPPORT PHASE

Activity	Product(s)
A. FOT&E.	A. Analogs of Test and Integration Phase products.
B. Construction, installation, & checkout of software maintenance & training faciilities.	B. Related documentation.
C. Software maintenance & modification.	C.1. New software Versions. 2. Version Description Documents. 3. Possible specification changes. 4. New or revised Test Plans and Test Procedures. 5. Additional tests. 6. Additional Test Reports.

APPENDIX A

THE SPECIFICATIONS

Not to be confused with the Description/Specifications (see SOWG, Section C2.2), the Specifications (e.g., the System Specification) are the RFP attachments that define the system and its parts. Thus, the Specifications are an essential part of an RFP for a contract that includes software development, since the effort contracted for is best defined relative to Specification provisions. This Appendix summarizes the major Specification provisions affecting software. Eventually the planned Software Acquisition Management Guidebook on Requirements Specification will be published covering the Specifications in more depth.

An RFP may include software-related specifications of several levels and types*, depending on the contractual approach, on the Acquisition Life Cycle Phase (see Section 2), and on the types of work and products being contracted for. Since the planned Software Acquisition Management Guidebook on Requirements Specification has yet to be written, this Appendix is provided to explain these different kinds of specifications briefly. Table A-1 depicts the structure and contents of the more important types of software-related specifications.

The RFP for a Conceptual Phase contract cannot normally include a System Specification (discussed in Section A1), since an Initial System Specification is a usual product of such a contract (see Section 3.3). However, the RFP should incorporate any documents that prescribe system requirements or suggest potentially feasible designs, as direction to, or guidance for, the contractor. Such documents include relevant extracts of any appropriate ROC, plus specifications for analogous systems, for interfacing systems, and for any subsystems already defined that the system being designed must incorporate.

In contrast, the RFP for a Conceptual Phase contract to provide software for feasibility demonstration or system simulation should definitely include a specification that clearly defines the desired product. This could be a Government-prepared Computer Program Development Specification (see Section A3).

An RFP for Validation Phase work should include the Initial System Specification, augmented by any other documents that modify the system's requirements. In particular, the System Specifications should include specifications of interfacing systems and of any subsystems whose inclusion in the planned system is required.

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* MIL-S-83490, Specifications, Types and Forms, and MIL-STD-490, paragraphs 1.3 & 3.1.3, briefly define the different prescribed specification types. ESD-TR-76-159 also discusses several types of specification.

Table A-1

Outlines of Software-Related Specification Types

Paragraph	Type A* System or Segment	Type B5** Computer Program Development	Type C5# Computer Program Product
1.	Scope	Scope	Scope
1.1		Identification	
1.2		Functional summary	
2.	Applicable documents	Applicable documents	Applicable documents
3.	Requirements	Requirements	Requirements (technical description)
3.1	System definition	Computer program definition	Functional allocation description
3.1.1	General description	Interface requirements	
3.1.1.1		Interface block diagram	
3.1.1.2		Detailed interface definition	
3.1.2	Missions		
3.1.3	Threat		
3.1.4	System diagrams		
3.1.5	Interface definition		
3.1.6	Government furnished property list		
3.1.7	Operational and organizational concepts		
3.2	Characteristics	Detailed functional requirements	Functional description
3.2.1	Performance characteristics	Function (first Function's name)	CPC (first CPC's name)

Table A-1 (Continued)

Paragraph	Type A* System or Segment	Type B5** Computer Program Development	Type C5# Computer Program Product
3.2.1.1		Inputs	Description: (first CPC's name)
3.2.1.2		Processing	Flow chart: (first CPC's name)
3.2.1.3		Outputs	Interfaces: (first CPC's name)
3.2.1.4		(Function, Inputs, Processing & Outputs are repeated for each other Function)	Data organization: (first CPC's name)
3.2.1.5			Limitations: (first CPC's name)
3.2.1.6			Listing: (first CPC's name) (The seven sections above are repeated for every other CPC)
3.2.n		Special requirements	
3.2.n.1		Human performance	
3.2.n.2		Government-furnished property list	
3.2.2	Physical characteristics		
3.2.3.-5	Reliability, maintainability & availability		
3.2.6	System effectiveness models		
3.2.7	Environmental conditions		
3.2.8	Nuclear control requirements		
3.2.9	Transportability		
3.3	Design and construction	Adaptation	Storage allocation

Table A-1 (Continued)

Paragraph	Type A* System or Segment	Type B5** Computer Program Development	Type C5# Computer Program Product
3.3.1	Materials, processes & parts	General environment	Data base characteristics
3.3.2	Electromagnetic radiation	System parameters	
3.3.3	Nameplates & product markings	System capacities	
3.3.4-6	Workmanship, interchangability & safety		
3.3.7	Human performance/ human engineering		
3.3.8	Computer programming		
3.4	Documentation		Computer program functional flow diagram
3.4.1			Program interrupts
3.4.2			Logic of subprogram reference
3.4.3			Special control features
3.5	*Logistics*		
3.6	*Personnel and training*		
3.7	*Functional area characteristics*		
3.8	*Precedence*		
4.	Quality assurance provisions	Quality assurance provisions	Quality assurance
4.1	General	Introduction	Test plan/procedure cross-reference index

Table A-1 (Concluded)

Paragraph	Type A* System or Segment	Type B5** Computer Program Development	Type C5# Computer Program Product
4.1.1	Responsibility for tests	Category I test	
4.1.2	Special tests & examinations	Computer programming test & evaluation	
4.1.3		Preliminary qualification tests	
4.1.4		Formal qualification tests	
4.1.5		Category II system test program	
4.2	Quality conformance inspections	Test requirements	Other quality assurance provisions
4.3		Acceptance test requirements	
5.	Preparation for delivery	Preparation for delivery	Preparation for delivery
5.1			Preservation and packaging
5.2			Markings
6.	Notes	Notes	Notes
10, 20, etc.	Appendices I, II, etc. (if any)	Appendices I, II, etc. (if any)	Appendices I, II, etc. (if any)

*Per MIL-STD-490, Appendix I, and MIL-STD-483(USAF), Appendix III.
**Per MIL-STD-490, Appendix VI, and MIL-STD-483(USAF), paragraph 60.4.
#Per MIL-STD-490, Appendix XIII, and MIL-STD-483(USAF), paragraph 60.5

The RFP(s) for Full-Scale Development Phase contracts should each include the Authenticated System Specification (see Section A1), any appropriate Segment Specification (see Section A2), and a subset of the Allocated Baseline (see Section 4.3.1) developed during the Validation Phase, by Government or contractor personnel. This subset should comprise a Computer Program Development Specification for each CPCI to be developed under the contract (see Section A3). Specifications of appropriate type for the CPCIs, equipment CIs, any other Segments, and any other systems, with which the software to be developed under the contract must interface should also be provided. (See Sections A4 and A5).

Software-related Production Phase and Deployment Phase RFPs should each incorporate the latest approved versions of the System Specification, any relevant Segment Specifications, all CPCI Development and CPCI Product Specifications (see Section A4), and analogous equipment specifications (see Section A5), pertinent to the planned software maintenance and modification.

One general policy is strongly recommended: never contract for substantial software development without sufficient, clear, specifications. For Operational Software and its Support Software these should include the latest approved version of the System Specification, any relevant Segment Specifications, and Development Specifications that incorporate a design of validated feasibility (see Section 4.3.2). Whenever such specifications are missing, incomplete, internally inconsistent, in conflict with other known requirements, or inadequately validated, software development is premature. Before a software development contract is let, further effort (perhaps itself contracted for) should rectify the deficiencies, even if schedules thereby slip. As further insurance against conflict and oversight, these specifications' relative Order of Precedence should be prescribed in the contract (see SOWG, Section C2.5.1.) Failure to follow the recommended procedure in past acquisitions has led to an inefficient software development process that sometimes caused serious cost overruns and schedule slips in the systems that included this software. The costs of sound specifications are usually repaid with interest in problems avoided later.

A1. The System Specification

The System Specification* (a Type A specification as defined in MIL-S-83490) is the highest level specification of a system. A System Specification is typically produced in at least two versions: an Initial System Specification developed during the Conceptual Phase (see Table 1, Set T), and an Authenticated System Specification (see Table 2, Set E) developed during the Validation Phase. In addition, either version of the System Specification may change as a result of ECP approvals after it has been baselined. (MIL-STD-480 discusses baselining, and control of subsequent specification changes.)

The Initial System Specification states the overall system requirements, but may identify the system's parts, and allocate requirements among them,

* Defined in MIL-STD-490, paragraph 3.1.3.1; in MIL-STD-483(USAF), paragraph 30; and in DI-E-3101, System Specification.

incompletely or imperfectly. These problems should be resolved in the Authenticated System Specification. The Authenticated (i.e., complete and validated) System Specification states the functional, performance, external interface, design, and testing requirements of the system as a whole. It identifies any System Segments (see Section 4.3.3); the Functional Areas (see Section 4.3.1) of each Segment (if any), or otherwise of the system as a whole; and the equipment CIs and CPCIs of each Functional Area. It allocates the overall system requirements among Segments (if any), the Functional Areas, and the CIs, and it specifies any other (non-allocated) requirements of each. Note that the System Specification may include constraints on the design and construction of the system and its parts. For example, per MIL-STD-483(USAF) (paragraph 30.5), System Specification paragraph 3.3.8 must include software design standards, identify prescribed programming languages, and state any other software design constraints, for systems that include software.

A2. The Segment Specification

If a system is to be segmented, Segment Specifications for one or more of its Segments are required under some circumstances. MIL-STD-483(USAF), paragraph 30.6, states the conditions under which Segment Specifications are mandatory; i.e.,

> "when a System or major equipment is acquired on an incremental basis or when a Segment(s) of an existing System is to undergo a major modification."

(Segment Specifications, like System Specifications, are Type A specifications). Where optional, a set of Segment Specifications may be judged an aid to specifying clear Segment requirements.

However, there are good reasons to avoid Segment Specifications if they are not mandated. First, if the System Specification properly characterizes and allocates requirements to each Functional area, Segment Specifications may be superfluous. Each Segment comprises one or more complete Functional Areas (see Section 4.3.3). Thus, each Segment's external interface requirements* are a subset of its Functional Areas' interface requirements. For the same reason each Segment's functional, design, performance and testing requirements are the composite of the corresponding requirements of the Functional Areas that belong to the Segment. Thus, a list of each Segment's Functional Areas, plus the System Specification's definition of these Functional Area characteristics and requirements, precisely define the Segment. Formal Segment definition can be accomplished by including in the System Specification a list of the Segments and the Functional Areas of each. This approach is recommended.

Second, and most important, avoiding Segment Specifications should reduce scattering of essential information about the system. Such scattering tends

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* The external interfaces of a system, Segment, or CI are its interfaces with systems, Segments, or CIs outside itself, in contrast to the interfaces among its parts, termed its internal interfaces.

to encourage ignorance and parochial views among the participants in a system acquisition, and eventually leads to inconsistencies that may entail extensive system modification during System Integration.

Third, having no Segment Specifications should save most of the effort and funds that their development and subsequent updating would entail.

A3. Computer Program Development Specifications

As part of the Allocated Baseline, a Computer Program Development Specification* (Type B5) must be produced for each CPCI to be developed. The Computer Program Development Specification defines the requirements against which the CPCI must be built. In contrast, a Computer Program Product Specification, which must be prepared during the CI's development, describes the software as built. (See Section A4). The correspondence between each CPCI's Computer Program Development Specification and its Computer Program Product Specification is recognized by subtitling them "Part I of Two Parts" and "Part II of Two Parts", respectively.

The Computer Program Development Specification defines a CPCI's requirements mainly in terms of its functions, its performance, its interfaces with equipment and other software, any constraints on its design, and the formal testing it must undergo. These statements of requirements are derived from, and must be consistent with, the CPCI's allocated requirements as stated in its Segment Specification (if any) and in the Authenticated System Specification. MIL-STD-483(USAF) (paragraph 60.4.3) permits incorporating by reference such System Specification and Segment Specification requirements in the Computer Program Development Specification. This approach is recommended, mainly to reduce omissions and inconsistencies both initially and during updating.

The Computer Program Development Specification not only references (or restates) the System (and possible Segment) Specification requirements allocated to the CPCI. It must also define the CI's parts, each called a Function,** and must impose requirements on each Function, thus detailing the system design to at least a third level (see Section 4.3.1). Thus, the Functions of a CI are not merely a simple allocation of system functions. For the reasons explained in Section 4.3.2, the Computer Program Development Specification should include all design requirements and other assumptions used in validating the system design, but should omit unvalidated design detail.

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* MIL-STD-490, paragraph 60, and MIL-STD-483(USAF), paragraph 60.4 prescribe Computer Program Development Specification form & content. DI-E-3119A, Computer Program Development Specification, supplements these military standards slightly.

** The Functions of a CI should not be confused with functional requirements or with the Functional Areas of a system (see Section 4.3.1).

Among the many types of requirements that a Computer Program Development Specification must define (explicitly or by reference) are the following:

a. each of the CPCI's Functions, plus the Function's input, processing, and output requirements; these should include any algorithms encompassed by the verified design;

b. the CPCI's external interfaces, physical & functional, including the characteristics of the computer on which it operates;

c. each message type that the CPCI must process, the message's format, and its maximum data rate;

d. any program structure, programming standards, programming languages, or specific compilers prescribed for the CPCI's development;

e. provisions for growth (e.g., extra core, channel capacity, and processing capacity);

f. special requirements (if any) for handling classified data;

g. features (e.g., trapping points) to facilitate testing;

h. any appropriate man-machine interface requirements (e.g., maximum display densities, maximum response time to terminal operator actions);

i. any Government-Furnished (GFP) software that the CPCI must incorporate;

j. any site adaptation parameters; and

k. the CPCI's overall workload-handling capacities.

Besides these mandatory provisions, a Computer Program Development Specification should specify the CPCI's main memory and auxiliary storage allocations, plus other assumptions, included in the verified system design (see Section 4.3.2).

In addition, the Computer Program Development Specification must state the requirements for testing the CPCI, but must <u>not</u> specify detailed test plans and test procedures. (These are normally prescribed in the SOW and CDRL as items for contractor development). Further, the Computer Program Development Specification must relate each of its testing requirements (termed Quality Assurance (QA) requirements) to one or more of the functional, performance, interface, or design requirements. This may be done by incorporating a Verification Matrix which identifies the QA requirement(s) and verification method(s) applicable to each functional, performance, interface, and design requirement. MIL-STD-483(USAF) (paragraph 60.4.4) defines four categories of Computer Program Development Specification QA requirements:

a. For Computer Program Test & Evaluation (i.e., informal testing to support CPCI development) QA requirements need be stated only to the extent necessary to collect relevant data unobtainable later.

b. For PQT, QA requirements need be defined only to assure correct operation of the CPCI's parts, if deemed necessary for simplified FQT, which tests the complete CPCI. Otherwise, QA requirements for these two testing phases are to be left unspecified, as contractor prerogatives.

c. In contrast, the Computer Program Development Specification must spell out all of the CPCI's FQT QA requirements.

d. The Computer Program Development Specification must also spell out CPCI QA requirements that must be deferred until Segment-level (if any) and system-level testing.

A4. Computer Program Product Specifications

A CPCI's Computer Program Product Specification* (Type C5) is produced during computer program development, to describe the CPCI as built. Usually at least a preliminary and a final version are prepared, the latter describing the complete and formally qualified CPCI.

The Computer Program Product Specification must fully describe the CPCI as a whole, each of its first-level parts, termed Computer Program Components (CPCs), and each CPC's structure. The CPCs may correspond more or less exactly to the Functions defined in the CPCI's Computer Program Development Specification (see Section A3), depending on the Development Specification's design constraints and on the developer's design approach. Unless there is exact correspondence, the contractor should be required to include in the Computer Program Product Specification a matrix that shows which CPCs satisfy each Function.

The overall CPCI description must show how the CPCI's storage is allocated, describe each data structure (i.e., file, table, individual data item) created or used, state which CPCs read and which alter each data structure component, list any site adaptation data, incorporate a top-level flowchart of the CPCI, and list & explain the impact of all program interrupts. For each CPC a description, a flowchart, an interface description, a structural description, a statement of limitations, and a listing are required. The CPC's programming language must also be identified. (A preliminary Computer Program Product Specification may omit listings of CPCs yet to be coded).

Per MIL-STD-483(USAF), paragraph 60.5.4.1, the QA provisions must explicitly cross-reference the Test Plan and Test Procedures used to qualify

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* Defined in MIL-STD-490, paragraph 130, and especially MIL-STD-483 (USAF), paragraph 60.5. DI-E-3120A, Computer Program Product Specification, supplements these.

the CPCI. The QA provisions must specify, too, additional tests that assure correct replication of the CPCI. The Computer Program Product Specification must also state requirements for packaging, mailing, shipping and storing the storage media that contain the CPCI.

The use of certain development methods may make it desirable for the Government to alter requirements, e.g., by DID modification, for the contents of Computer Program Product Specifications. For example, if Structured Programming is used, conventional flowcharts may be superfluous.

A5. Other Relevant Specifications

Specification of equipment, other software, and other systems, with which software to be developed, maintained or modified must interface, is also essential. MIL-STD-490 and MIL-STD-483(USAF) define specification types applicable to equipment CIs developed as parts of Major Defense Systems. However, some of a CPCI's interfacing software, equipment, or other systems may be defined in commercial or other specifications. Such non-standard specifications should be reviewed thoroughly before including them in an RFP, to assure their adequacy (see Section 4.3.1) for their intended uses.

LIST OF ABBREVIATIONS

Abbreviation	Definition
AFLC	Air Force Logistics Command
AFSC	Air Force Systems Command
AFTEC	Air Force Test and Evaluation Center
ASPR	Armed Services Procurement Regulations
ATC	Air Training Command
BA/PA	Budget Authorization/Program Authorization
CCB	Configuration Control Board
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CI	Configuration Item
CPC	Computer Program Component
CPCI	Computer Program Configuration Item
CPDP	Computer Program Development Plan
CRISP	Computer Resources Integrated Support Plan
CRWG	Computer Resource Working Group
CWBS	Contract Work Breakdown Structure
DCP	Decision Coordinating Paper
DID	Data Item Description
DoD	Department of Defense
DODD	Department of Defense Directive
DODI	Department of Defense Instruction
DSARC	Defense Systems Acquisition Review Council
DT&E	Development Test and Evaluation
ECO	Engineering Change Order
ECP	Engineering Change Proposal
ESD	Electronic Systems Division
FCA	Functional Configuration Audit
FCRC	Federal Contract Research Center
FOT&E	Follow-on Operational Test and Evaluation
FQR	Formal Qualification Review
FQT	Formal Qualification Test
GFP	Government-Furnished Property
ICD	Interface Control Drawing
ICWG	Interface Control Working Group
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
PBS	Program Breakdown Structure
PCA	Physical Configuration Audit
PCO	Procuring Contracting Officer
PDR	Preliminary Design Review
PM	Program Manager
PMD	Program Management Directive
PMP	Program Management Plan
PMRT	Program Management Responsibility Transfer
PO	Program Office

LIST OF ABBREVIATIONS (Concluded)

Abbreviation	Definition
PQT	Preliminary Qualification Test
QA	Quality Assurance
R&D	Research and Development
RFP	Request for Proposal
ROC	Required Operational Capability
SA	Supplemental Agreement
SAF	Secretary of the Air Force
SCN	Specification Change Notice
SECDEF	Secretary of Defense
SDR	System Design Review
SEMP	System Engineering Management Plan
SOW	Statement of Work
SOWG	Software Acquisition Management Guidebook: Statement of Work Preparation
T&E	Test and Evaluation
TBD	To be Determined
TEMP	Test & Evaluation Master Plan
TEOA	Test and Evaluation Objectives Annex (of the PMD)
V&V	Validation and Verification
WBS	Work Breakdown Structure

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4.	MIL-S-52779(AD) 5 April 1974	Software Quality Assurance Program Requirements
5.	MIL-S-83490 30 October 1968	Specifications, Types and Forms
6.	MIL-STD-480 30 October 1968	Configuration Control - Engineering Changes, Deviations and Waivers
7.	MIL-STD-483(USAF) including Notice 1 1 June 1971	Configuration Management Practices for Systems, Equipment, Munitions, and Computer Programs
8.	MIL-STD-490 including Change 2 18 May 1972	Specification Practices
9.	MIL-STD-499A(USAF) 1 May 1974	Engineering Management
10.	MIL-STD-881A 25 April 1975	Work Breakdown Structures for Defense Materiel Items
11.	MIL-STD-1521(USAF) including Change 2 2 January 1975	Technical Reviews and Audits for Systems, Equipment, and Computer Programs

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24. DI-E-3120A
Computer Program Product Specification

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25. Joseph T. Connolly, Software Acquisition Management Guidebook: Regulations, Specifications and Standards, ESD-TR-75-91 (MTR-3080, Contract F19628-75-C-0001, The MITRE Corporation, Bedford, Mass.), October 1975.

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* The Regulations, Specifications, Standards, and DIDs cited are those in effect at the time the research for the guidebook was completed. Since that time new versions of, or changes to, some of them have been issued. Readers who want the latest version of a reference should check official sources.

** Additional DIDs are referenced in Tables 1-3.